ISBN 0-7729-2916-5

AQUATIC ENVIRONMENT OF HUMBER BAY

JUNE 1988

Ontario
Ministry of the Environment

Jim Bradley
Minister

AQUATIC ENVIRONMENT

OF

HUMBER BAY

Edited by M. Griffiths

June 1988

Water Resources Branch
Ontario Ministry of the Environment

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ISBN 0-7729-2916-5

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EXECUTIVE SUMMARY

1. INPUT LOADINGS

Sources of pollutants to Humber Bay have been identified as the Humber River, Mimico Creek, the Humber Sewage Treatment Plant (STP), combined sewer overflows (CSOs), storm sewers and direct atmospheric deposition to Humber Bay. The Humber STP and the Humber River are the primary sources of metal and phosphorus inputs. The Humber River is the predominant source of suspended solids.

The Humber STP, CSOs and the Humber River dominate the bacterial loading to the Bay. However, the Humber STP loadings occur largely during the winter season when the effluent is not chlorinated. During the summer, the CSO and Humber River bacterial inputs are more significant, especially in association with wet weather events.

No direct monitoring of atmospheric deposition to Humber Bay has been carried out. Some conservative loadings were estimated from data collected in agricultural areas. As depositional loadings may be significantly higher in heavily industrialized areas, atmospheric deposition has the potential to be significant.

2. WATER QUALITY

During wet weather, elevated phosphorus levels (greater than 20 ug/L) were found in 25% of Humber Bay. Fecal coliform levels in excess of 100 org/100 mls were associated with a similar size zone following rain.

Metals in levels above Provincial Water Quality Objectives (PWQO) were found near some input sources in the case of cadmium, copper, iron, lead, nickel and zinc. Copper is possibly the most significant metal of concern as it was frequently found in concentration above those considered adequate to protect aquatic life.

Several organochlorine compounds were detected near the input sources. These included trichlorobenzene, tetrachlorobenzene, α, β and γ BHC, pentachlorophenol and HCB (hexachlorobenzene). All of the above were found in trace amounts only and were never found to exceed the existing PWQO. PCBs and DDTs were not found in the waters of Humber Bay at present detecton levels based on this limited sampling.

3. DRINKING WATER SUPPLY (R.L. Clark)

To date, the drinking water from the nearby R.L. Clark water filtration plant has not exceeded any Ontario Drinking Water Objectives or any guidelines for drinking water set by other jurisdictions such as the U.S. Environmental Protection Agency or the World Health Organization.

4. BODY CONTACT RECREATION

The most bacteriologically impacted beach in Humber Bay is Amos Waites followed by Sunnyside and Boulevard Club.

Beaches west of the Humber River (including Amos Waites) have been permanently posted by the Etobicoke Department of Public Health for many years as a result of historically high bacterial levels. Beaches east of the Humber River (the Western Beaches) have been intermittently posted by the City of Toronto Department of Public Health since the summer of 1983.

Local storm sewer runoff appears to have a minor effect on the Etobicoke nearshore west of the Humber River. On the other hand inputs from the Humber River and from large storm and combined overflow sewers located east of the Humber River have a pronounced effect on bacterial levels along the Western Beaches. Discharges from the Humber River and from these sewers have the potential to intrude through the semi-permeable breakwall back on to the beaches.

5. AESTHETICS

Sections of the Humber Bay nearshore zone are experiencing aesthetic quality impairment associated with accumulations of the filamentous alga Cladophora. Elevated nutrient levels and substrate availability are responsible for these nuisance aquatic growths.

6. IN-PLACE POLLUTANTS

Of future concern may be the need to dredge certain sections of Humber Bay, notably the eastern embayment of Humber Bay Waterfront Area which is slowly becoming filled in by suspended sediment input from the Humber River. Since the sediment in this embayment is contaminated at levels above MOE dredging guidelines, future dredging and dredged spoil disposal will have to be conducted in an environmentally acceptable manner. The contaminated material has elevated levels of phosphorus, cadmium, copper, chromium, lead, zinc, solvent extractables and PCBs.

7. SPORT FISH

A potential concern with respect to sport fishing relates to chemical contamination of sport fish leading to restrictions on consumption. In Humber Bay, lake trout larger than 45 cms have been found to exceed acceptable levels of PCB and Mirex in their flesh, and are suitable only for limited consumption. Contamination of sport fish caught in Humber Bay may not be necessarily related only to local inputs. For instance, Mirex found in lake trout probably originated predominantly from the Niagara River. The origin of PCB contamination in sport fish collected in the Bay is likely a combination of local as well as lake-wide inputs. Restoration of the fishery must therefore proceed on basis of lake-wide abatement strategy and must address all major inputs and not only those associated with Toronto Waterfront.

8. AQUATIC BIOTA

The benthic invertebrate community in the vicinity of major inputs has been found to be disrupted. An area of 120,000 m^2 near the Humber STP outfall has been shown to be devoid of any benthic organisms. Construction of the Humber Bay Waterfront Area also appears to have had a detrimental impact on the local benthic community. In areas affected by nutrient-rich plumes from Humber River and Mimico Creek, a benthic community indicative of highly enriched conditions has developed.

Local fish communities continue to accumulate contaminants. Although PCB levels in spottail shiners have declined in recent years, they still exceed the IJC Aquatic Life Guideline of 100 ppb for the protection of fish-consuming birds and animals. The biota associated with sediments also has been found to bioaccumulate chemicals including the metals mercury, zinc, copper and organic compounds such as PCBs, DDD, DDE, HCB, α BHC, chlordane, heptachlor and aldrin.

9. REMEDIAL PROGRAMS AND RELATED STUDIES

In response to beach postings in 1983, the Humber Bay area has undergone aesthetic rehabilitation. In addition, numerous studies and programs have been initiated with the aim of developing remediation strategies for the entire Toronto waterfront.

A comprehensive remedial action plan (RAP) for the Toronto waterfront is presently being developed by the Ontario and Federal Governments in an effort to provide a strategy for abatement which would result in an improved aquatic environment.

The Ontario Ministry of the Environment has embarked on a "Municipal-Industrial Strategy for Abatement" (MISA) which is aimed at controlling municipal and industrial discharges into surface waters.

In 1981, the Ontario Ministry of the Environment initiated the Toronto Area Watershed Management Strategy (TAWMS), aimed at developing abatement measures for the Don River, Humber River and Mimico Creek watersheds. While this program is primarily intended to foster water quality improvement in the rivers themselves, it will significantly benefit Toronto waterfront quality as well. Implementation of the Humber River Water Quality Management Plan is presently underway.

Concurrently with TAWMS, the Ministry has entered into agreements with the Municipality of Metropolitan Toronto to provide funds to the local municipalities for special remedial works and investigations (MOE/Metro Agreement).

SOMMAIRE

1. SOURCES DE POLLUANTS

On a découvert que les sources des polluants déversés dans la baie de Humber sont la rivière Humber, le ruisseau Mimico, l'usine d'épuration des eaux d'égout de Humber (UEE), les déversoirs d'orage (DO), les égouts pluviaux et les retombées atmosphériques directes dans la baie. Les principales sources de métaux et de phosphore sont l'UEE de Humber ainsi que la rivière Humber; cette dernière constitue en outre la principale source de solides en suspension.

La plus grande partie des eaux contaminées par des bactéries provient de l'UEE de Humber, des DO et de la rivière Humber. Cependant, l'UEE de Humber contribue à cette contamination surtout en hiver, lorsque les eaux traitées ne sont pas chlorées. Pendant l'été, l'apport de bactéries des DO et de la rivière Humber est plus important, particulièrement par temps pluvieux.

On n'a procédé à aucune surveillance directe des retombées atmosphériques dans la baie de Humber. On a effectué des évaluations prudentes à partir des données recueillies dans les régions agricoles. Ces retombées peuvent se révéler importantes, étant donné qu'il s'agit de régions fortement industrialisées.

2. QUALITÉ DE L'EAU

Par temps pluvieux, on a relevé des concentrations élevées de phosphore (supérieures à 20 ug/L) dans une zone représentant 25 % de la baie de Humber. Des concentrations de coliformes fécaux dépassant 100/100 mL ont été mesurées dans une zone de dimensions semblables après de la pluie.

Des concentrations de cadmium, de cuivre, de fer, de plomb, de nickel et de zinc supérieures aux objectifs relatifs à la qualité de l'eau en Ontario ont été mesurées près de certaines sources. Le cuivre est probablement le métal qui suscite le plus d'inquiétudes car il a souvent été mesuré à des concentrations supérieures à celles qui sont considérées acceptables pour la vie aquatique.

Plusieurs composés organochlorés ont été détectés près des sources de polluants, dont le trichlorobenzène, le tétrachlorobenzène, l'hexachlorobenzène (alpha, bêta et gamma), le pentachlorophénol et l'hexachlorure de carbone. Tous ces composés ne se trouvaient qu'à l'état de traces et respectaient les objectifs relatifs à la qualité de l'eau en Ontario. Les concentrations de BPC et de DDT que contenaient les échantillons prélevés dans la baie de Humber n'atteignaient pas les seuils de détection actuels.

3. EAU POTABLE (R.L. Clark)

Jusqu'à maintenant, l'eau potable provenant de l'usine de filtration R.L. Clark a respecté les objectifs provinciaux relatifs à la qualité de l'eau potable ainsi que toutes les lignes directrices se rapportant à l'eau potable établies par d'autres organismes tels que la Environmental Protection Agency des États-Unis ou l'Organisation mondiale de la santé.

4. LOISIRS AQUATIQUES

La plage la plus contaminée par les bactéries de la baie de Humber est la plage Amos Waites, suivie de celles de Sunnyside et de Boulevard Club.

Les plages situées à l'ouest de la rivière Humber (y compris Amos Waites) sont interdites par le service de santé publique d'Etobicoke depuis de nombreuses années en raison des concentrations élevées de bactéries. Les plages situées à l'est de la rivière Humber (Western Beaches) sont interdites de temps à autre par le service de santé publique de la ville de Toronto depuis l'été 1983.

Les déversements des égouts pluviaux de la région semblent avoir un effet négligeable sur le rivage à l'ouest de la rivière Humber, à Etobicoke. Cependant, les apports de la rivière Humber ainsi que des égouts pluviaux et des déversoirs d'orage importants situés à l'est de la rivière Humber ont une influence marquée sur les concentrations de bactéries le long des Western Beaches. Les polluants provenant de la rivière Humber et de ces égouts peuvent s'infiltrer à travers la digue semi-perméable et se rendre jusqu'aux plages.

5. DÉTÉRIORATION ESTHÉTIQUE

Certaines parties du littoral de la baie de Humber ont subi une détérioration esthétique en raison de la prolifération de l'algue filamenteuse Cladophora. La croissance de cette végétation nuisible est imputable à l'abondance de substances nutritives et du substrat.

6. SÉDIMENTS CONTAMINÉS

Il faudra peut-être envisager dans l'avenir le dragage de certaines parties de la baie de Humber, notamment la section est du littoral qui se comble progressivement de sédiments en suspension provenant de la rivière Humber. Étant donné que les sédiments de ce secteur sont contaminés à des concentrations supérieures aux lignes directrices du MEO en matière de dragage,

le dragage et l'élimination des sédiments dragués devront se faire de manière à ne pas nuire à l'environnement. Les matières contaminées contiennent des concentrations élevées de phosphore, de cadmium, de cuivre, de chrome, de plomb, de zinc, de substances extractibles par solvants et de BPC.

7. PÊCHE SPORTIVE

La contamination du poisson par les produits chimiques, qui oblige à restreindre la consommation, constitue une source d'inquiétudes du côté de la pêche sportive. Dans la baie de Humber, on a constaté que les touladis d'une longueur supérieure à 45 cm contenaient des concentrations de BPC et de mirex supérieures aux normes et leur consommation doit être limitée. La contamination des poissons pêchés dans la baie de Humber n'est peut-être pas nécessairement attribuable à des sources locales. Par exemple, le mirex décelé dans les touladis vient sans doute du Niagara. Les BPC présents dans les poissons de la baie viennent probablement de sources locales aussi bien que d'autres sources situées ailleurs sur les rives du lac. Le rétablissement de la pêche doit donc s'effectuer en fonction d'une stratégie de dépollution du lac entier et doit tenir compte de toutes les grandes sources de polluants, et non seulement de celles du littoral de Toronto.

8. FAUNE ET FLORE AQUATIQUES

On a découvert que les invertébrés benthiques avaient été touchés dans les environs des grandes sources de polluants. On a constaté qu'une superficie de 120 000 m^2 près de l'exutoire de l'UEE de Humber est entièrement dépourvue d'organismes benthiques.

Il semble également que l'aménagement des rives de la baie de Humber ait eu des répercussions néfastes sur les organismes benthiques de l'endroit. Dans les régions recevant des substances riches en éléments nutritifs provenant de la rivière Humber et du ruisseau Mimico, la communauté benthique qui s'est développée reflète la qualité des conditions qui y règnent.

Les populations locales de poissons continuent d'accumuler les polluants. Bien que les concentrations de BPC dans les queues à tache noire aient diminué depuis quelques années, elles dépassent toujours la concentration maximale indiquée dans les lignes directrices de la CMI en matière de vie aquatique, c'est-à-dire 100 ppb, pour la protection des oiseaux et autres animaux piscivores. Les organismes présents dans les sédiments sont sujets à la bioaccumulation de produits chimiques, notamment les métaux tels que le mercure, le zinc, le cuivre, ainsi que les composés organiques comme les BPC, le DDD, le DDE, l'hexachlorure de carbone, l'hexachlorobenzène 2, le chlordane, l'heptachlor et l'aldrine.

9. PROGRAMMES D'ASSAINISSEMENT ET ÉTUDES CONNEXES

En réponse aux interdictions de baignade de 1983, la région de la baie de Humber a subi des améliorations sur le plan esthétique. En outre, de nombreux programmes et études ont été entrepris dans le but d'élaborer des stratégies d'assainissement des eaux de tout le littoral de Toronto.

Le gouvernement de l'Ontario et le gouvernement fédéral élaborent actuellement un plan d'assainissement complet pour le littoral de Toronto afin d'arriver à une stratégie de dépollution qui permette d'améliorer l'environnement aquatique.

Le ministère de l'Environnement de l'Ontario a entrepris la mise en oeuvre de la Stratégie municipale et industrielle de dépollution (SMID) dont le but est de lutter contre la pollution due aux déversements municipaux et industriels dans les eaux de surface.

En 1981, le ministère de l'Environnement de l'Ontario a entrepris la Stratégie de gestion des bassins versants de la région torontoise qui vise à élaborer des mesures de dépollution des bassins versants des cours d'eau Don, Humber et Mimico. Bien que ce programme vise d'abord à améliorer la qualité de l'eau de ces cours d'eau, il améliorera également de manière appréciable la qualité de l'eau de tout le littoral de Toronto. La mise en oeuvre du Plan de gestion de la qualité de l'eau de la rivière Humber est actuellement en cours.

Pour compléter la Stratégie de gestion des bassins versants de la région torontoise, le Ministère a conclu des accords avec la Communauté urbaine de Toronto afin d'aider les municipalités de la région à financer des recherches et des travaux d'assainissement spéciaux (Accord MEO/Communauté urbaine de Toronto).

1.0 INTRODUCTION

Humber Bay is part of the Toronto Waterfront which, for a number of years, has been identified as a Great Lakes area of concern by the International Joint Commission (IJC). This designation is based on the discovery of organic contaminants and metals in the sediments of the area, presence of trace contaminants (metals, organics) in water and local biota, elevated nutrient levels, and bacterial contamination, particularly in response to runoff conditions.

Recent beach postings by the City of Toronto and Etobicoke Departments of Public Health have resulted in a heightened public awareness of Toronto pollution problems and have led to a number of studies aimed at identifying the sources of contamination, documenting the extent of environmental degradation and developing abatement strategies. This report summarizes the findings of these studies and reports on the status of remedial programs.

2.0 DESCRIPTION OF THE AREA

Humber Bay is the largest of all embayments situated along the north shore of Lake Ontario. The Bay is bordered by the City of Toronto to the east of the Humber River and by the City of Etobicoke to the west of the river. Major waterfront-related uses are graphically presented in Figure 2.1.1 and are briefly described below.

East of the Humber River, the shoreline is gently sloping and readily accessible along the Western Beaches which form a continuous sandy strip, stretching for approximately 2 km, as far as the Boulevard Club. The sandy beach is bordered to the north by parkland providing recreational facilities such as playgrounds and picnic areas. The Sunnyside pool and adjacent sandy beach serve as focal points for swimming activity in the area.

East of the Western Beaches, the shoreline is generally more steeply sloping and thus less suitable for swimming. Nevertheless, it does

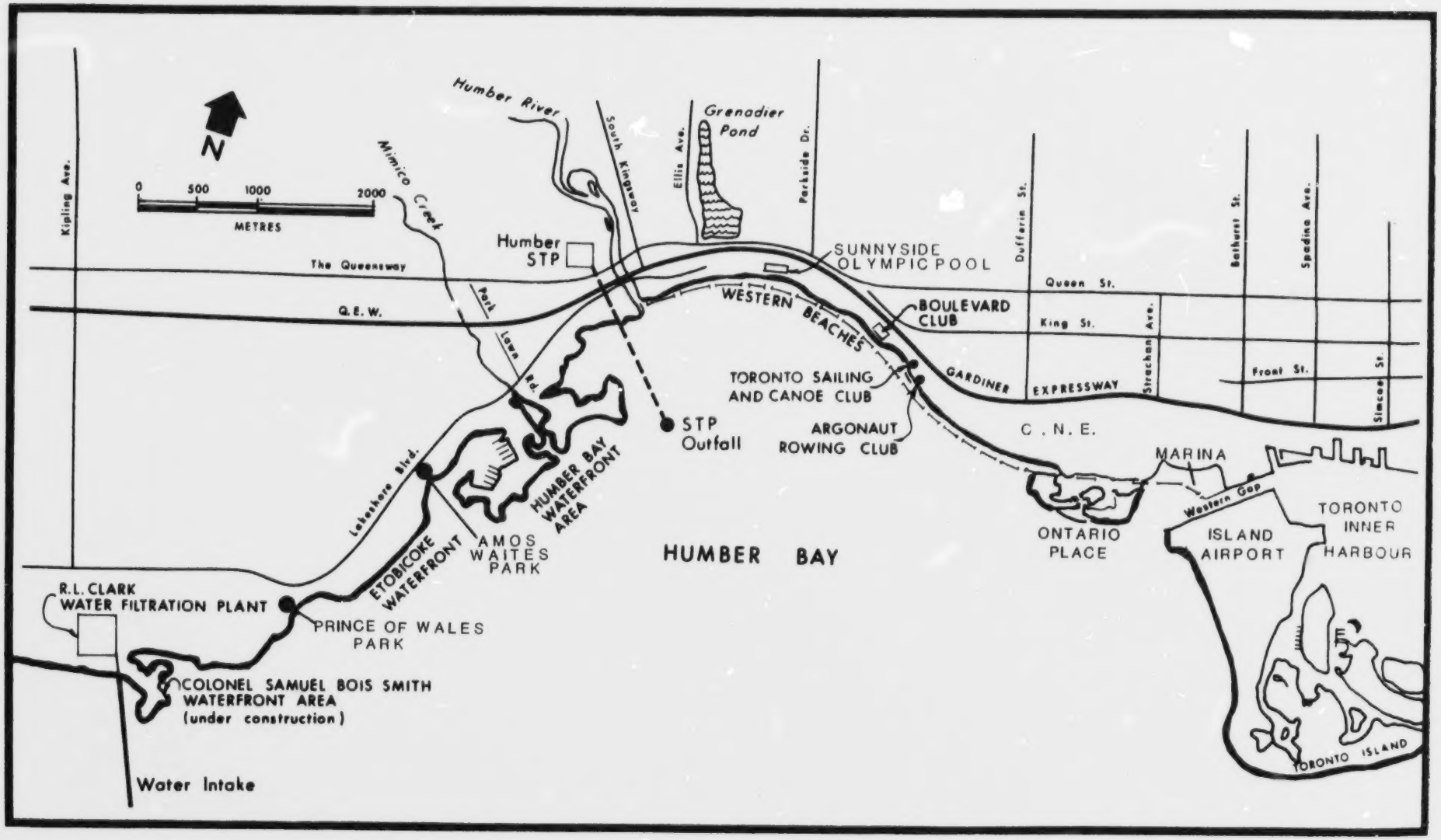


FIGURE 2.1.1 WATERFRONT USES OF HUMBER BAY AREA

Amos Waites beach is one of very few accessible sandy spots along the Etobicoke shore of Humber Bay.

Rocky groins built to stabilize the Etobicoke shoreline are favourite fishing spots for children.

Private ownership along the Etobicoke shoreline of Humber Bay is common.

Boulders armouring this Etobicoke shoreline of Humber Bay provide a perfect substrate for the growth of a nuisance filamentous alga Cladophora.

One of the playgrounds along the Western beaches frequented by flocks of geese.

Well groomed Western beaches have been widened recently with additions of sand.

A series of breakwalls protects the Western beaches from wave activity and provides a quiescent environment for boat mooring.

provide a base for other water-related recreational facilities such as the Toronto Sailing and Canoe Club, the Argonaut Rowing Club, and a number of marinas. Further east lies Ontario Place, a man-made system of islands which harbours an entertainment complex, and, together with the CNE, serves as a site for Aquarama during the late summer.

In contrast to the Western Beaches, the shoreline west of the Humber River (the Etobicoke sector) is consideraby less accessible to the public, partly because of extensive private shoreline ownership (motels, Palace Pier condominium, apartments, houses) and partly because of generally precipitous access to the water's edge. The public can access the lake only at a number of small parks (Rotary, Prince of Wales, Amos Waites) and the Humber Bay Waterfront Area. No suitable lake swimming opportunities exist in this sector, partly because of lack of sizeable sand beaches and partly because of permanent postings by the Etobicoke Health Department warning against polluted water and advising against swimming and wading.

The Humber STP discharge directly to Humber Bay in the vicinity of the Humber Bay Waterfront Area. Just west of the Humber Bay is the R.L. Clark Water Filtration Plant which supplies the City of Etobicoke with drinking water.

3.0 DESCRIPTION OF ENVIRONMENTAL CONDITIONS

3.1 WATER MOVEMENT

Physical Processes

The nearshore physical processes are the mechanisms that transport and disperse the contaminants discharged to the nearshore areas. These processes can vary dramatically between locations and with time. Unlike the coastal regions of the oceans where the physical processes have a definite tidal periodicity the nearshore lake processes can be dominated by many different physically definable periodicities a number of which can predominate at a particular time. Selecting a period for averaging in the nearshore zone is, therefore, not simple. It is not possible to state that monthly or seasonal circulation patterns predominate (based on current meter data) because the patterns change from year to year.

Thermal stratification and upwelling/downwelling are two characteristics that affect the currents in the nearshore regions of Humber Bay during the summer. While the mean surface water temperature in the summer months may be fairly similar from year-to-year, the rate of lake water warming may be very different. Similarly upwelling/downwelling episodes caused by winds are not necessarily characteristic of any particular month.

In the western waterfront area recording current meters have been deployed in various locations over a period of years (see Figure 3.1.1). These provide data on the time variation of current speed, direction and water temperature at constant time intervals.

The usual analysis of data produces frequency tables of direction and speed in certain intervals (sectors of a compass), maximum, mean, minimum speed, net velocity and persistence (Tables 3.1.1A and 3.1.1B). Additionally progression vector, autocorrelation and spectral function, and time series plots are produced on graphic plotters (Figures 3.1.2A-D). These statistics only apply to the location where the measurements were taken and are known as Eulerian data. The data are generally different for each calendar period from one year to another as discussed previously.

Individual location recording current meter data cannot be used to predict the impact of a discharge. The statistics can be used to identify locations where there are extended periods of small currents, the periods of high velocities and the prevailing directions of the currents. This information may be useful in explaining local areas of water quality degradation or predicting poor areas for a discharge. To use the data from a recording current meter location to predict the effect of a discharge it is necessary to combine concurrent measurements at many locations and use a numerical model to develop the area circulation pattern for any period of interest. Because the circulation pattern varies with time, the pattern must be developed for a period of concern or an episode. The episodes of interest can be

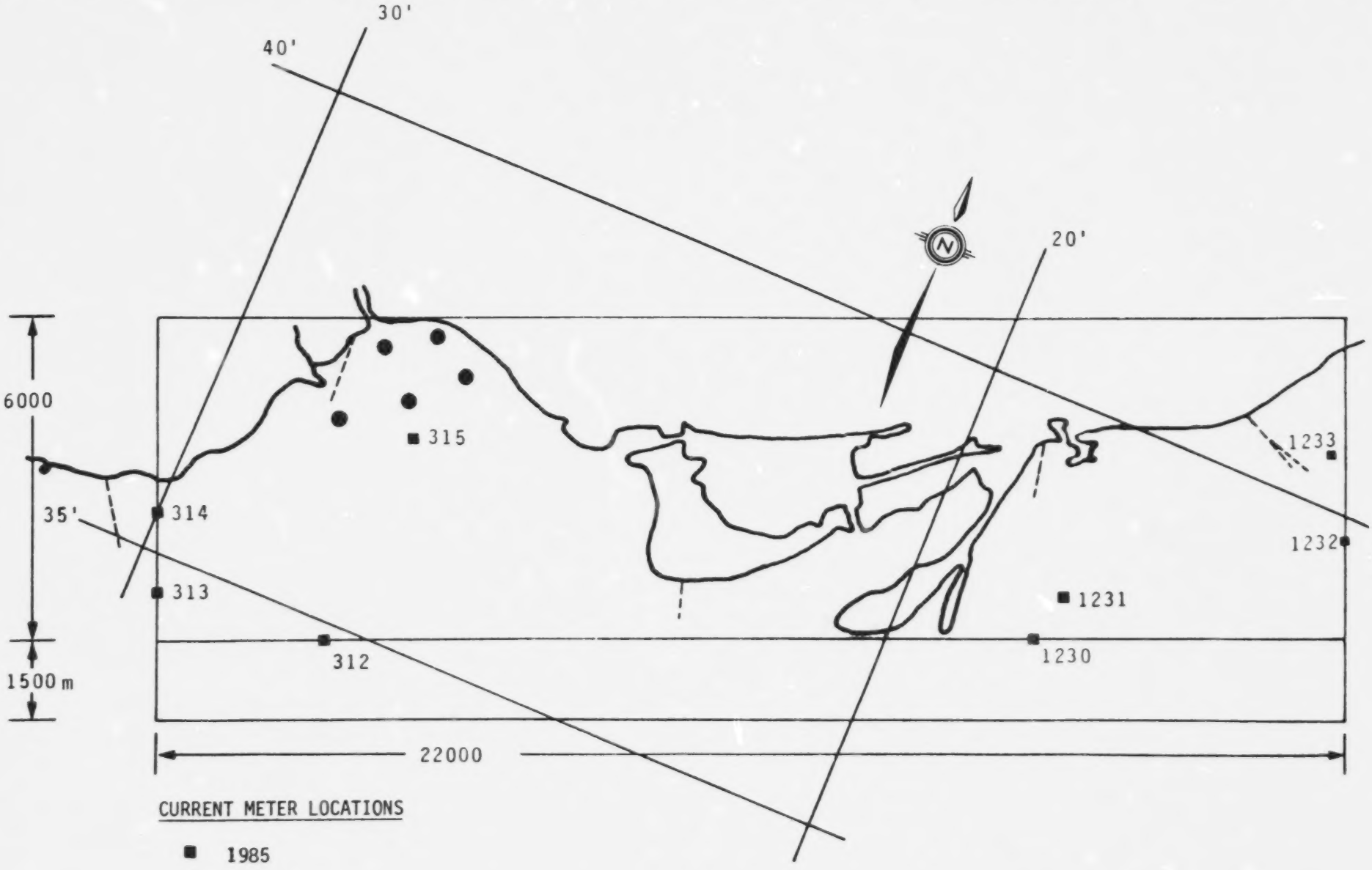


FIGURE 3.1.1: CURRENT METER LOCATIONS

TABLE 3.1.1A

LOCATION CODE: 0315
AREA : HUMBER BAY
LAKE : LAKE ONTARIO
PERIOD : JUL 1985
LATITUDE : 43 36 55 N
LONGITUDE: 79 27 09 W
ANGLE FROM MAGNETIC NORTH TO SHORELINE IS 30 DEGREES CLOCKWISE

FREQUENCY TABLE

	DIRECTION IN DEGREES								
SPEED (CM/S)	337.50-22.49	22.50-67.49	67.50-112.49	112.50-157.49	157.50-202.49	202.50-247.49	247.50-292.49	292.50-337.49	ROW SUMS
1.50 -- 2.99	2.48	6.15	4.77	1.24	2.89	4.41	1.88	1.70	25.52
3.00 -- 4.99	2.52	8.81	4.73	2.25	1.88	2.80	.64	1.56	25.20
5.00 -- 6.99	1.93	7.02	4.82	1.97	.96	2.48	2.57	1.28	23.04
7.00 -- 8.99	.87	3.26	1.93	1.01	.64	1.15	1.33	1.70	11.89
9.00 -- 10.99	.73	1.24	1.33	1.06	.87	.96	.28	.46	6.93
11.00 -- 12.99	.41	.69	1.47	.28	.05	.05	.09	.09	3.12
13.00 -- 14.99	.00	.96	1.74	.00	.00	.14	.09	.00	2.94
15.00 -- 20.80	.00	.05	.41	.00	.00	.00	.92	.00	1.38
COLUMN SUMS	8.95	28.18	21.20	7.80	7.30	11.98	7.80	6.79	100.00

RESULTANT CURRENT IS 1.75 CM/S AT 65 DEG. FROM MAG. NORTH
MEAN CURRENT IS 5.51 CM/S
MAXIMUM CURRENT IS 20.80 CM/S
MINIMUM CURRENT IS 1.50 CM/S

TOTAL NO. OF POINTS 2179
PERSISTANCE IS .32
READINGS TAKEN EVERY 10MINS.

METER OPERATIONS

METER OPERATED AT 4M FROM BOTTOM IN 19.5M OF WATER

STARTED AT .05 HRS. ON 1ST DAY OF JUL 1985
ENDED AT .00 HRS. ON 16TH DAY OF JUL 1985

TABLE 3.1.1B

LOCATION CODE: 0315 PERIOD : JUN 1985
AREA : HUMBER BAY LATITUDE : 43 36 55 N
LAKE : LAKE ONTARIO LONGITUDE: 79 27 09 W
ANGLE FROM MAGNETIC NORTH TO SHORELINE IS 330 DEGREES CLOCKWISE

FREQUENCY TABLE

	DIRECTION IN DEGREES								
SPEED (CM/S)	337.50-22.49	22.50-67.49	67.50-112.49	112.50-157.49	157.50-202.49	202.50-247.49	247.50-292.49	292.50-337.49	ROW SUMS
1.50 -- 3.99	3.08	9.45	6.70	3.08	1.77	3.77	1.48	1.23	30.56
4.00 -- 5.99	1.63	6.34	5.25	5.00	1.85	2.17	2.10	1.19	25.52
6.00 -- 7.99	2.14	4.96	6.05	3.01	1.52	1.05	1.48	1.67	21.87
8.00 -- 9.99	.51	3.04	2.28	1.77	.62	1.16	.91	.40	10.68
10.00 -- 11.99	.54	1.12	1.77	1.12	.14	.87	.11	.04	5.72
12.00 -- 13.99	.25	.98	1.92	.69	.00	.00	.11	.14	4.09
14.00 -- 15.99	.00	.14	.54	.25	.00	.00	.00	.00	.94
16.00 -- 18.90	.00	.04	.51	.04	.00	.00	.04	.00	.62
COLUMN SUMS	8.15	26.07	25.02	14.95	5.90	9.02	6.23	4.67	100.00

RESULTANT CURRENT IS 2.60 CM/S AT 83 DEG. FROM MAG. NORTH TOTAL NO. OF POINTS 2762
MEAN CURRENT IS 5.85 CM/S PERSISTANCE IS .44
MAXIMUM CURRENT IS 18.90 CM/S READINGS TAKEN EVERY 10MINS.
MINIMUM CURRENT IS 1.50 CM/S

METER OPERATIONS

METER OPERATED AT 4M FROM BOTTOM IN 19.5M OF WATER

STARTED AT 19.55 HRS. ON 11TH DAY OF JUN 1985
ENDED AT .00 HRS. ON 30TH DAY OF JUN 1985

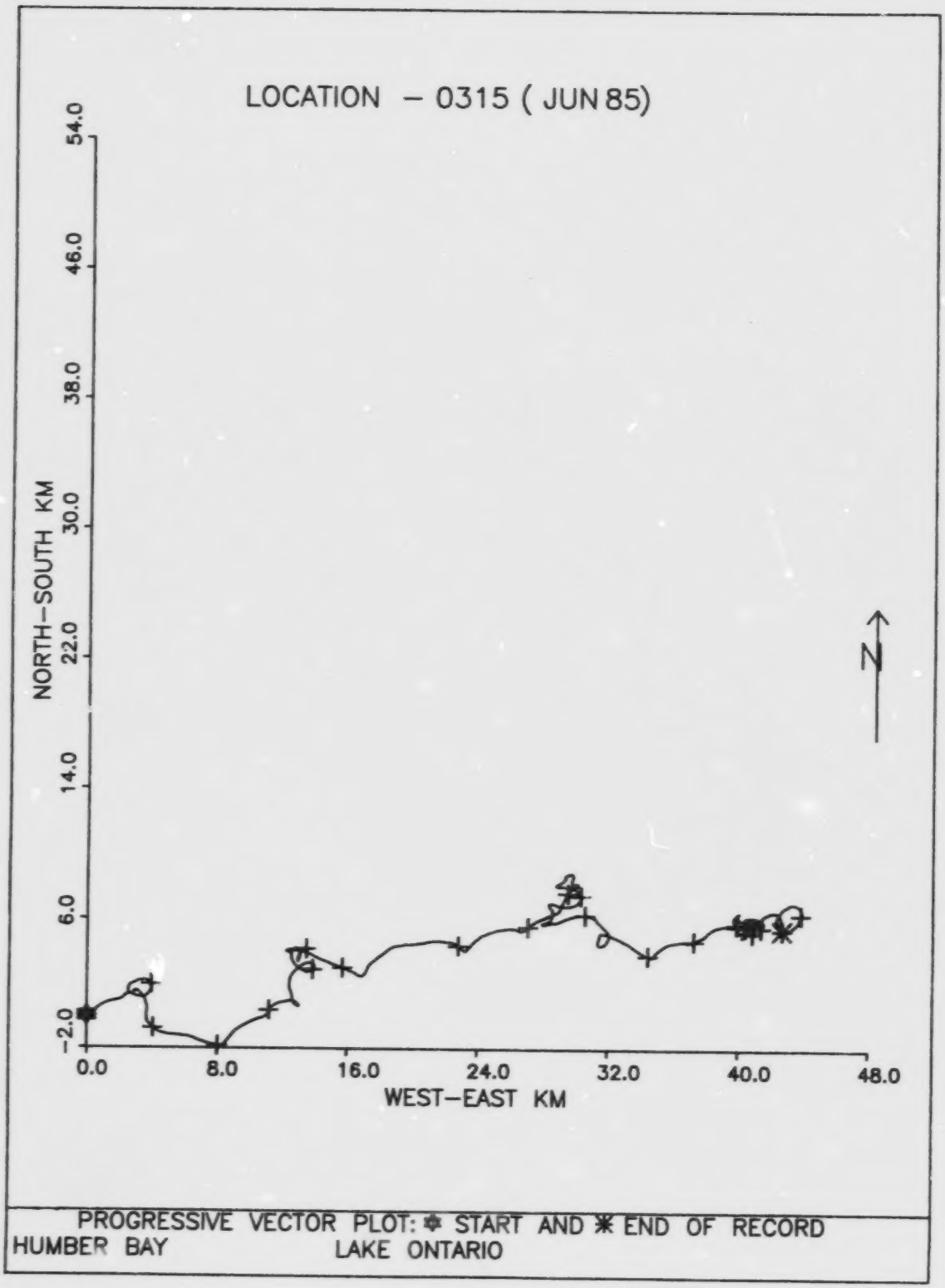
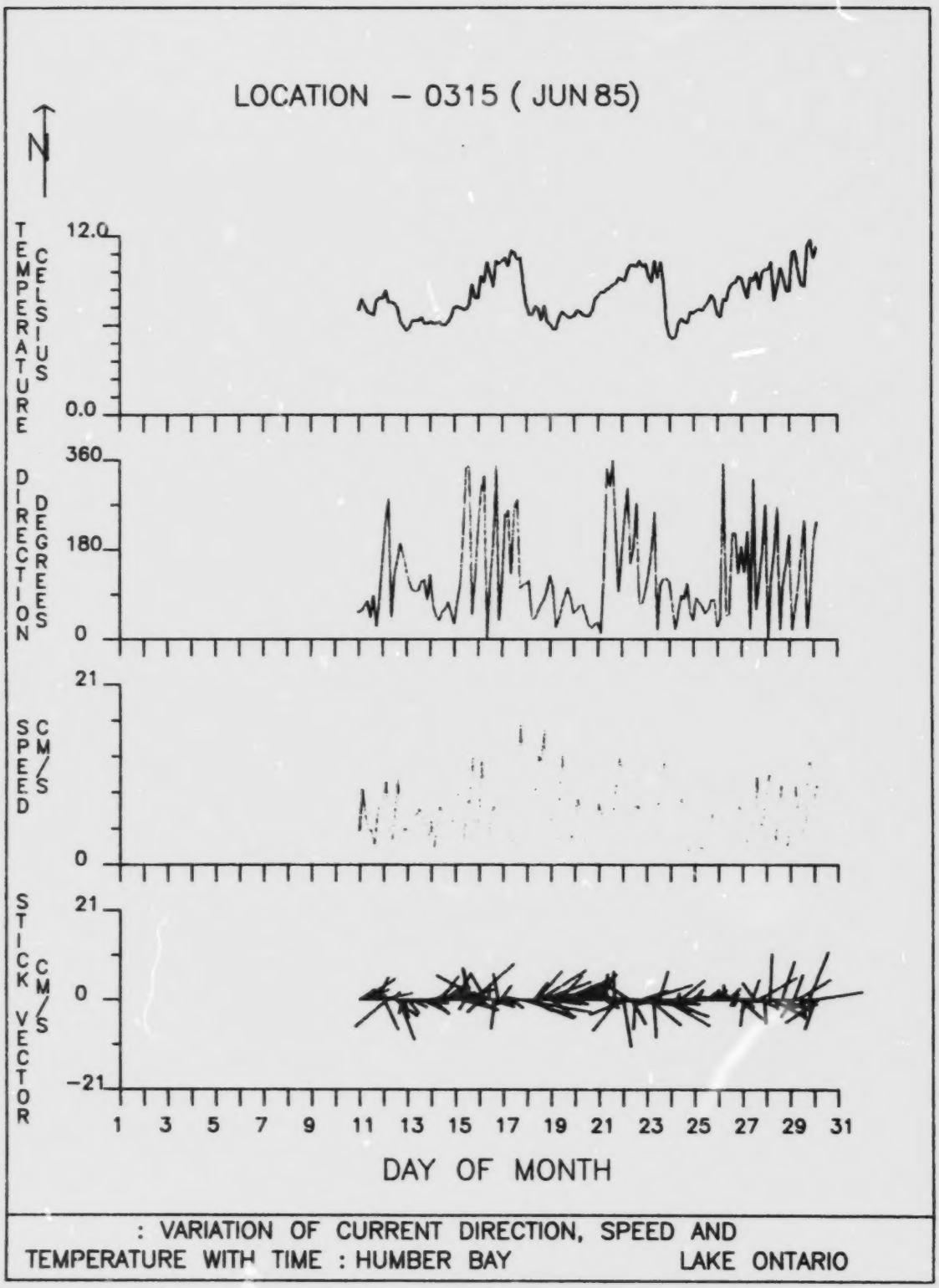
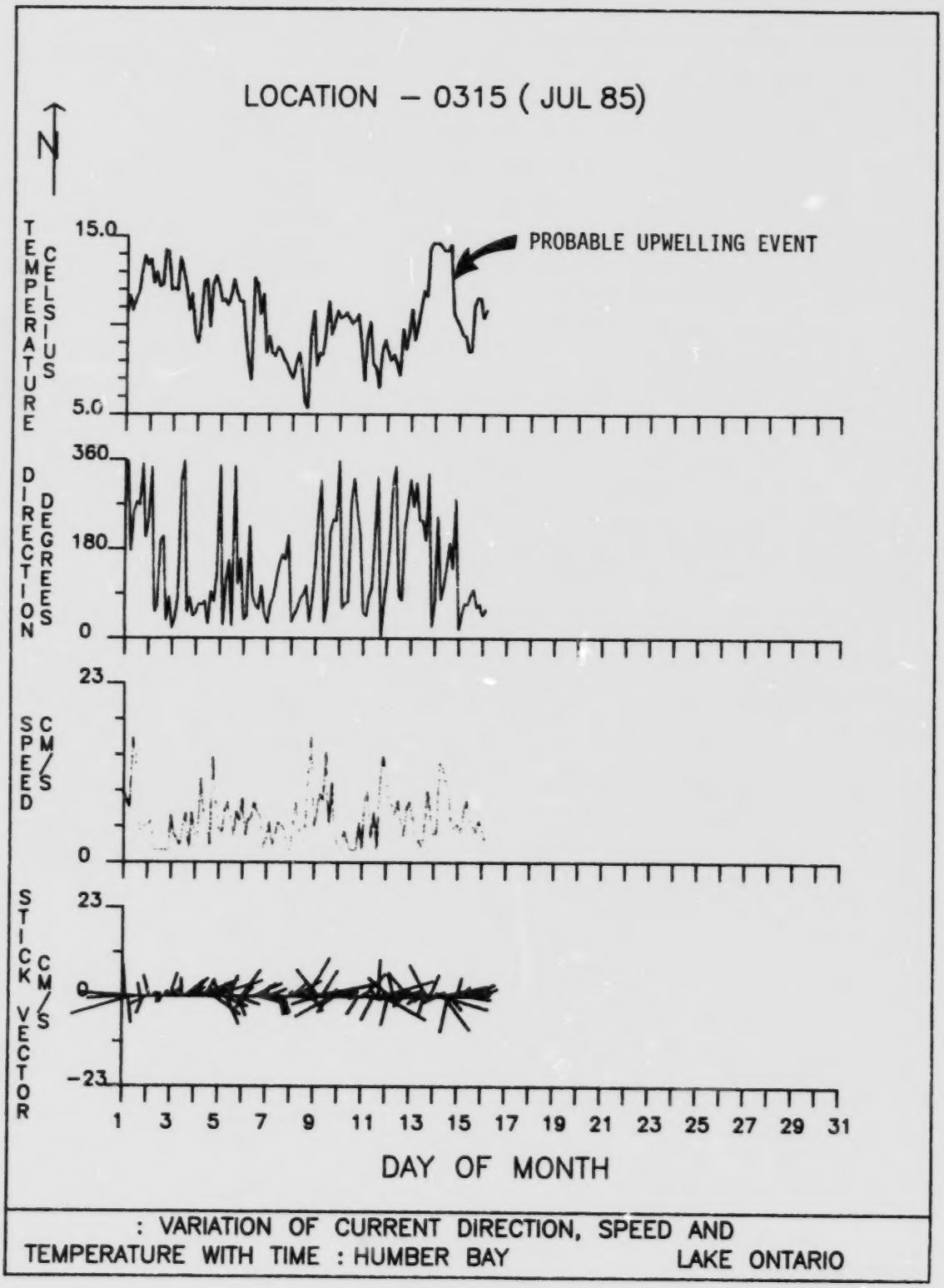

LOCATION – 0315 (JUN 85)
NORTH–SOUTH KM
54.0
46.0
38.0
30.0
22.0
14.0
6.0
-2.0
0.0
8.0
16.0
24.0
32.0
40.0
48.0
WEST–EAST KM
N
PROGRESSIVE VECTOR PLOT: ✲ START AND ✳ END OF RECORD
HUMBER BAY
LAKE ONTARIO

FIGURE 3.1.2 A



: VARIATION OF CURRENT DIRECTION, SPEED AND TEMPERATURE WITH TIME : HUMBER BAY LAKE ONTARIO

FIGURE 3.1.2 B



: VARIATION OF CURRENT DIRECTION, SPEED AND TEMPERATURE WITH TIME : HUMBER BAY LAKE ONTARIO

FIGURE 3.1.2 C

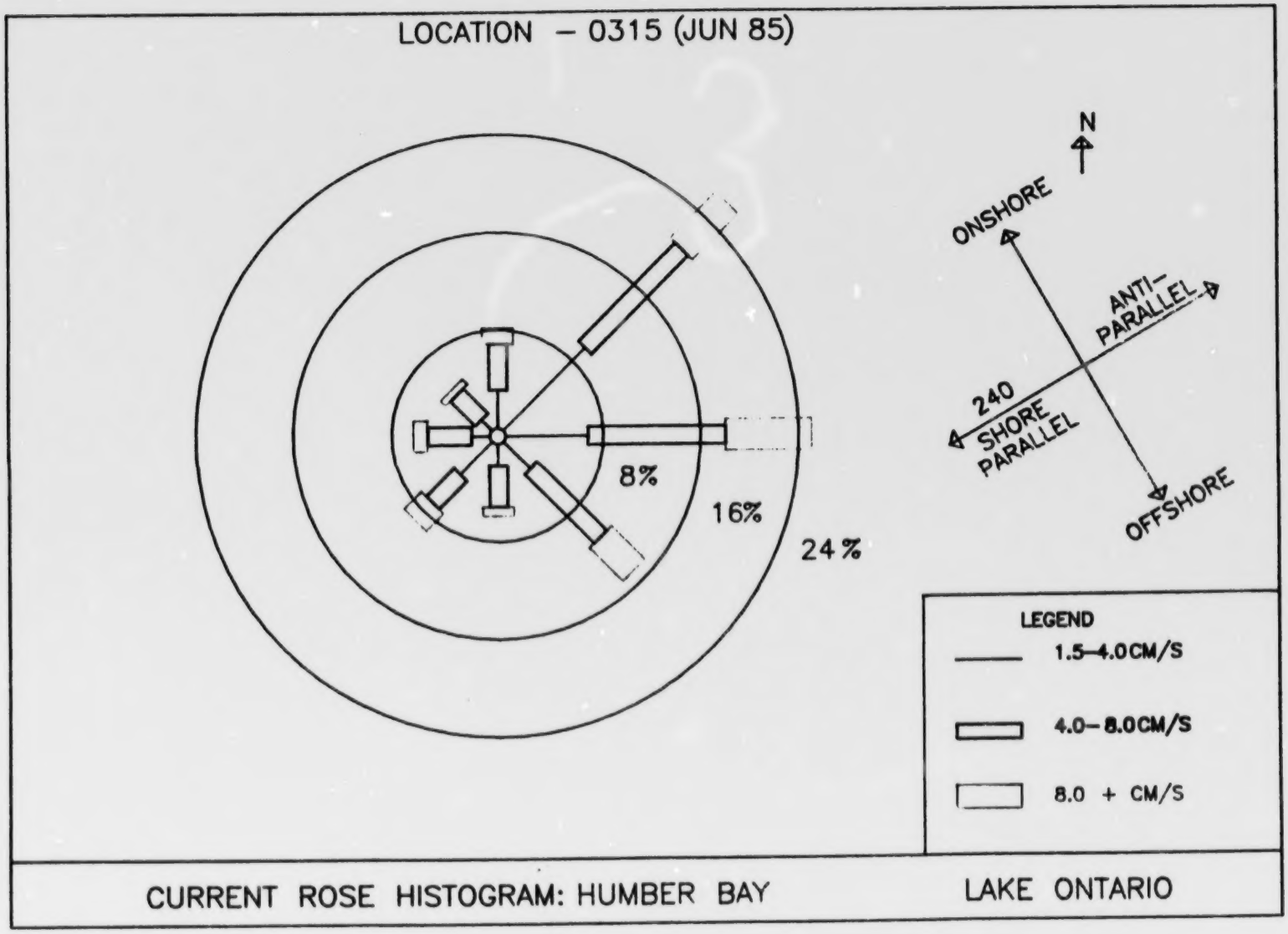

LOCATION – 0315 (JUN 85)
N
ONSHORE
ANTI–
PARALLEL
240
SHORE
PARALLEL
OFFSHORE
8%
16%
24%
LEGEND
1.5–4.0CM/S
4.0–8.0CM/S
8.0 + CM/S
CURRENT ROSE HISTOGRAM: HUMBER BAY
LAKE ONTARIO

FIGURE 3.1.2 D

selected from recording current meter histories. Prediction models have been developed for the Toronto Waterfront which will predict the impact of a discharge to the waterfront for any episode (see Figures 3.1.3 to 3.1.4). The model requires the real time inputs from recording current meters, wind data, and the measured bathymetry and shoreline geometry. General recording meter data from a single location as indicated previously is only of value in terms of defining locations with little movement, high magnitude currents and the predominate directions of current movement.

During the testing of the Toronto Waterfront Model, one current meter #315 (see Figure 3.1.2.B,C), was used to check the performance of the model prediction. It was found that there was virtually no correlation between the predictions and meter #315. The reason for this was that this particular meter, during the period of simulation, had regular oscillations in direction and large fluctuations in the speed component (June 15-18, 27-30). This disturbance was either a lake seiche, upwelling/downwelling or wind effect. The first two causes should also have been observed at the other meters in the area, but were not. The meter location is in the bay, possibly sheltered by the shoreline geometry, so that the daily wind shift from onshore to offshore as the result of diurnal heating was considered responsible for the meter swing. The model is driven by the boundary current meters, and these did not exhibit the oscillations so the forcing required to generate the current swings was not present. This also illustrates that currents can vary greatly over distances of several hundred meters.

The current meter data for 1983-1984 have been analysed by Kohli (1986). The records were divided into months and the mean monthly velocity vector plotted for each meter (Figure 3.1.5). The vectors display different patterns of circulation for the various seasons. The summer circulation was east to west with occasional weak counter-clockwise gyres in the middle of the bay. The circulation reversed in the winter season and had generally higher speeds. The western waterfront speeds were slower than the eastern waterfront data. These patterns should only be considered representative of conditions which occurred during the period of measurement.

TORONTO WATERFRONT

VELOCITY VECTORS START TIME 85-6-16 10:0

TIME STEP 960 HOUR 32.002
WESTERLY FLOW
WIND 2. M/S FROM 120. THIS PLOT 85-6-17 18:0

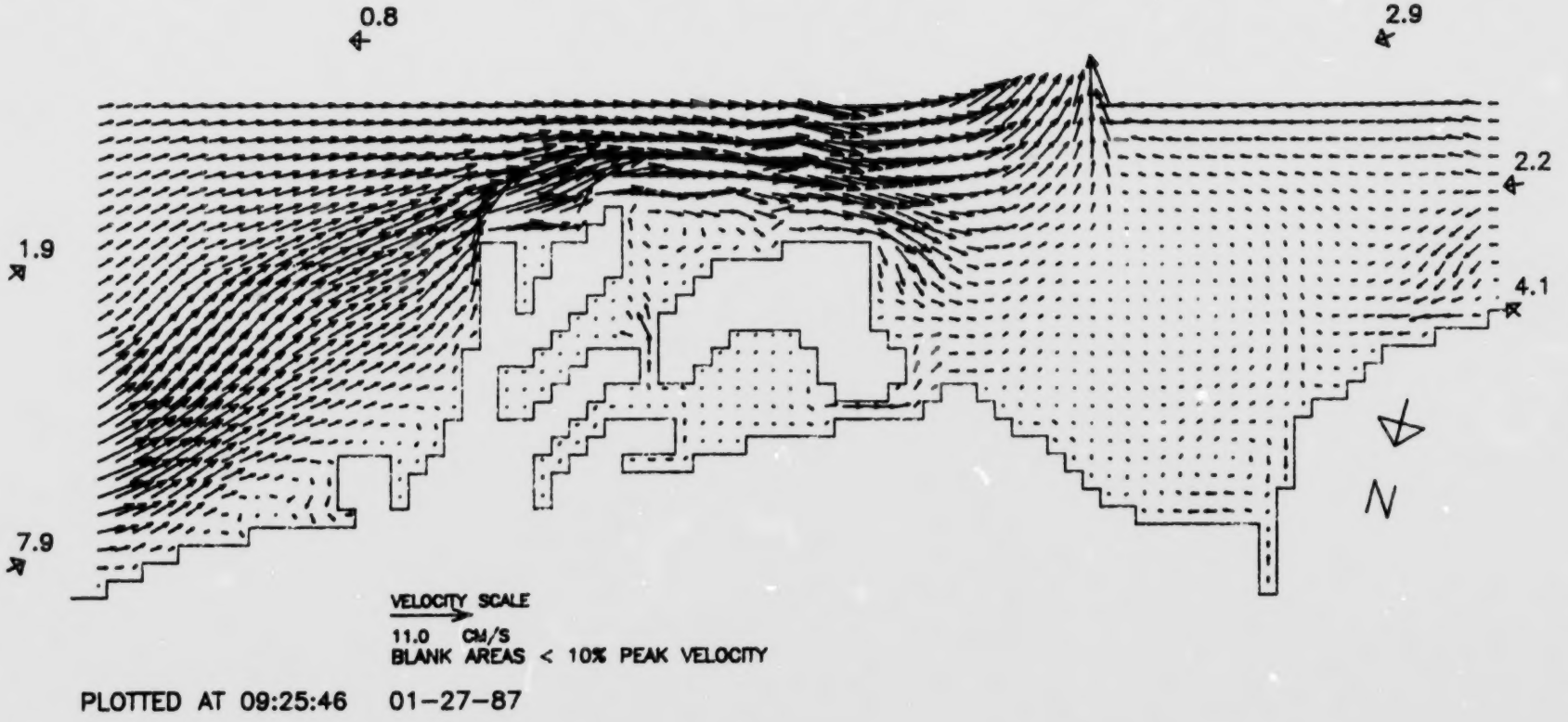


FIGURE 3.1.3 - VELOCITY VECTORS

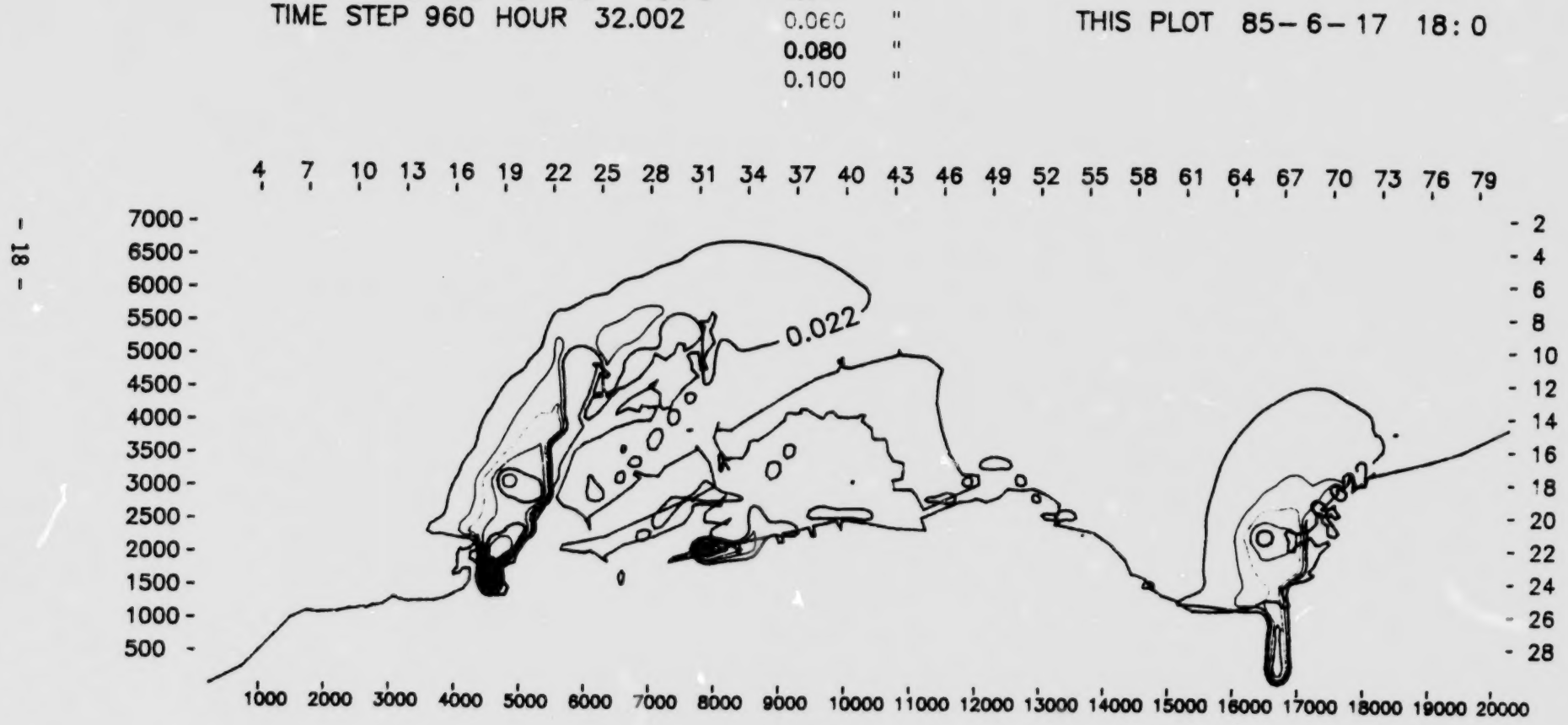


FIGURE 3.1.4

PHOSPHORUS LEVELS

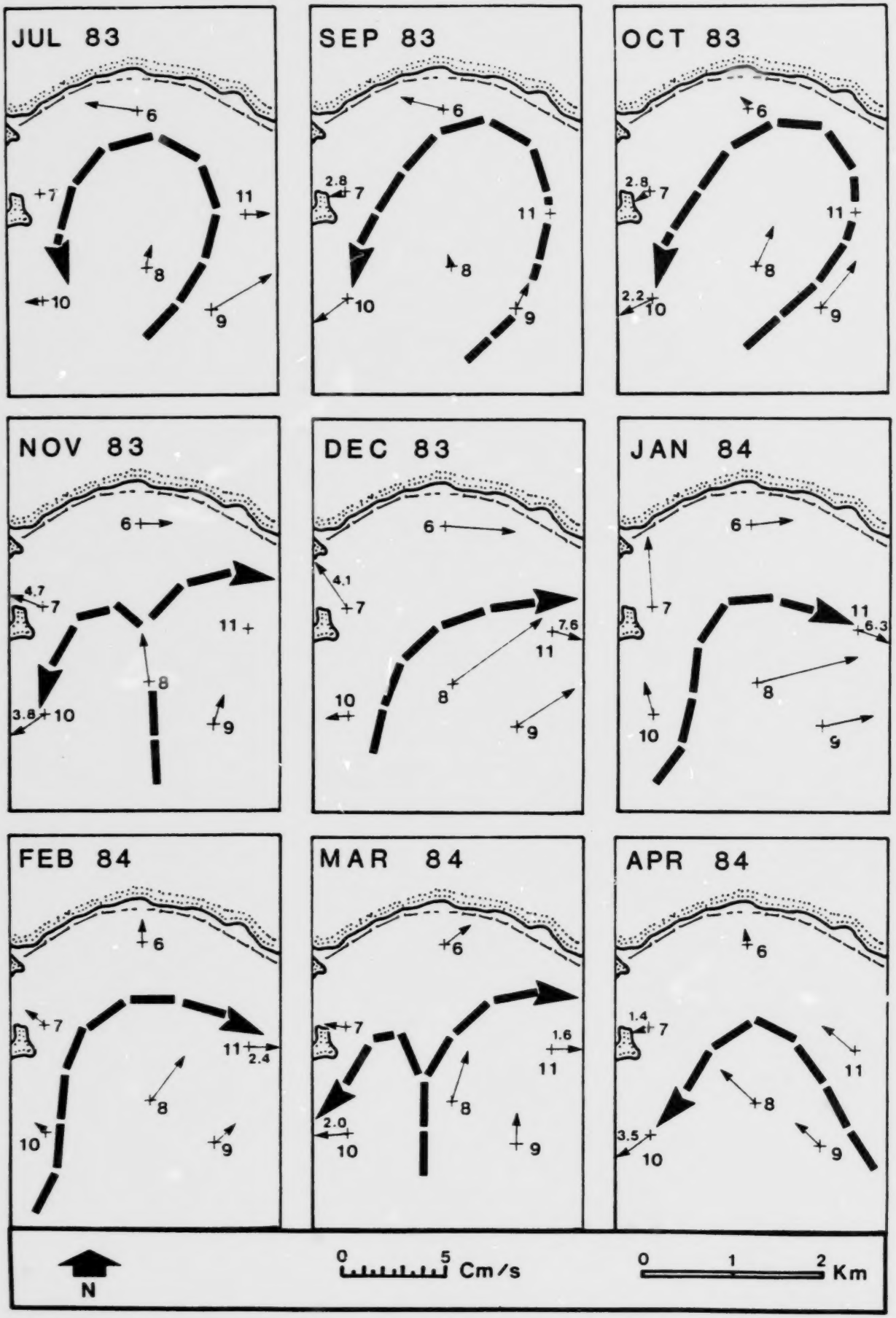


FIGURE3.1.5: FLOW PATTERN, HUMBER BAY, LAKE ONTARIO, 1983-84

Several upwelling events were observed at all locations during August and September. These events are characterized by decreases in the water temperature recorded at the current meter (Figure 3.1.2C). Such events provide a complete mass exchange between the onshore and offshore zones.

Recent beach closings on the western beaches have resulted in several studies to examine the effects of the Humber River, Humber STP outfall and storm sewer plumes on the levels of fecal coliforms in the area, as well as mixing and transport behind the breakwater.

The first evidence of the Humber River plume affecting the inner breakwater water quality came from aerial photographs. The surface river turbidity plume was observed to enter the breakwater at the river outlet and move eastward. A deflector jetty was constructed at the river mouth in late 1984. The jetty did not close off the breakwater gap entirely.

Subsequent aerial photographs have shown that the surface Humber River plume can still move through the gap and travel eastward. A time lapse video of the Humber River mouth (Hunter 1985) found intrusions as far as the third gap. The intrusion occurrences are listed below:

intrusion to first gap	68% of the time
intrusion to second gap	5% of the time
intrusion to third gap	3% of the time
no intrusions	24% of the time

A full listing is given in Table 3.1.2.

These intrusions are for the surface Humber River. It is not known from these studies whether the intrusions are merely a surface phenomena.

TABLE 3.1.2: IMAGE ANALYSIS SUMMARY

	Observations	
	% of total	number
Plume Colour		
Brown	48.5	357
Intermediate	25.8	190
Sediment	25.6	189
Total		736
Plume Outflow Direction		
South	29.8	203
Southeast	22.3	152
East	32.3	220
Confined	7.7	53
Confined/South	6.9	47
Confined/Southeast	0.7	5
Confined/East	0.2	1
Total		681
Plume Intrusion (by no. of breakwalls)		
1/2 and greater	60.6	214
1 and greater	20.1	137
2 and greater	3.7	25
Image Quality		
Haze	14.0	104
Fog	9.6	71
Rain	6.2	46
Clear	70.2	520
Total		741
Plume East Extent (by no. of breakwalls)		
1/2 and greater	35.3	239
1 and greater	10.6	72
2 and greater	0.9	6

NOTE: Total daytime observations are estimated at 780.

A limited drogue tracking study (MOE, 1985) using water sail drogue clusters showed that the river water can intrude through the gaps between the concrete-caped breakwater structures during southerly winds. The water sail drogue, unlike the aerial photographs, measure the movement of the surface 1.5 m of water. A dye experiment has shown that the breakwaters are permeable below the water line and consequently transport can occur through the breakwater (Kleinfeldt 1986). Figures 3.1.6A-D show the probable circulation patterns in the gaps as measured by dye and drogue tracking.

A model prediction study, using a fine resolution grid (30m) of just the nearshore area of the Western Beaches has been used to study the impact of the storm sewers and Humber on the Western Beaches. The current patterns for an easterly and westerly current condition in the lake are shown in Figures 3.1.7A-B. The resultant flow is well behaved since no oscillations occur, however the boundary conditions here are simplified and somewhat artificial since only one current meter was available to provide data on the currents. A more realistic model prediction would require at least 4 current meters.

Storm water fecal coliform pollutographs were generated for the July 17th, 1986 event (10 mm total rainfall) and September 22nd, 1986 event (15 mm total rainfall). The July 17th event was more intense in the lower parts of the Humber River drainage basin near the lake whereas the September 22nd event was more intense in the upstream parts of the basin. When the numerical receiving water model with easterly flowing currents is used to predict the impact of the local storm sewer discharges and the Humber River on beach fecal coliform densities it was found that the sewer discharges accounted for 85% of the fecal coliform loadings for July 17th (see Figure 3.1.8) and a negligible loading for September 22nd (see Figure 3.1.9). Because summer rainstorms can vary significantly in intensity over distances of a few kilometers it is not possible to generalize about the relative impact of runoff from the Humber River and the storm sewers on beach fecal coliform densities. The relative impact is directly related to the stormwater flows generated in the sewers and the Humber River. In general the effect of the Humber River persists for a longer period due to its larger drainage area.

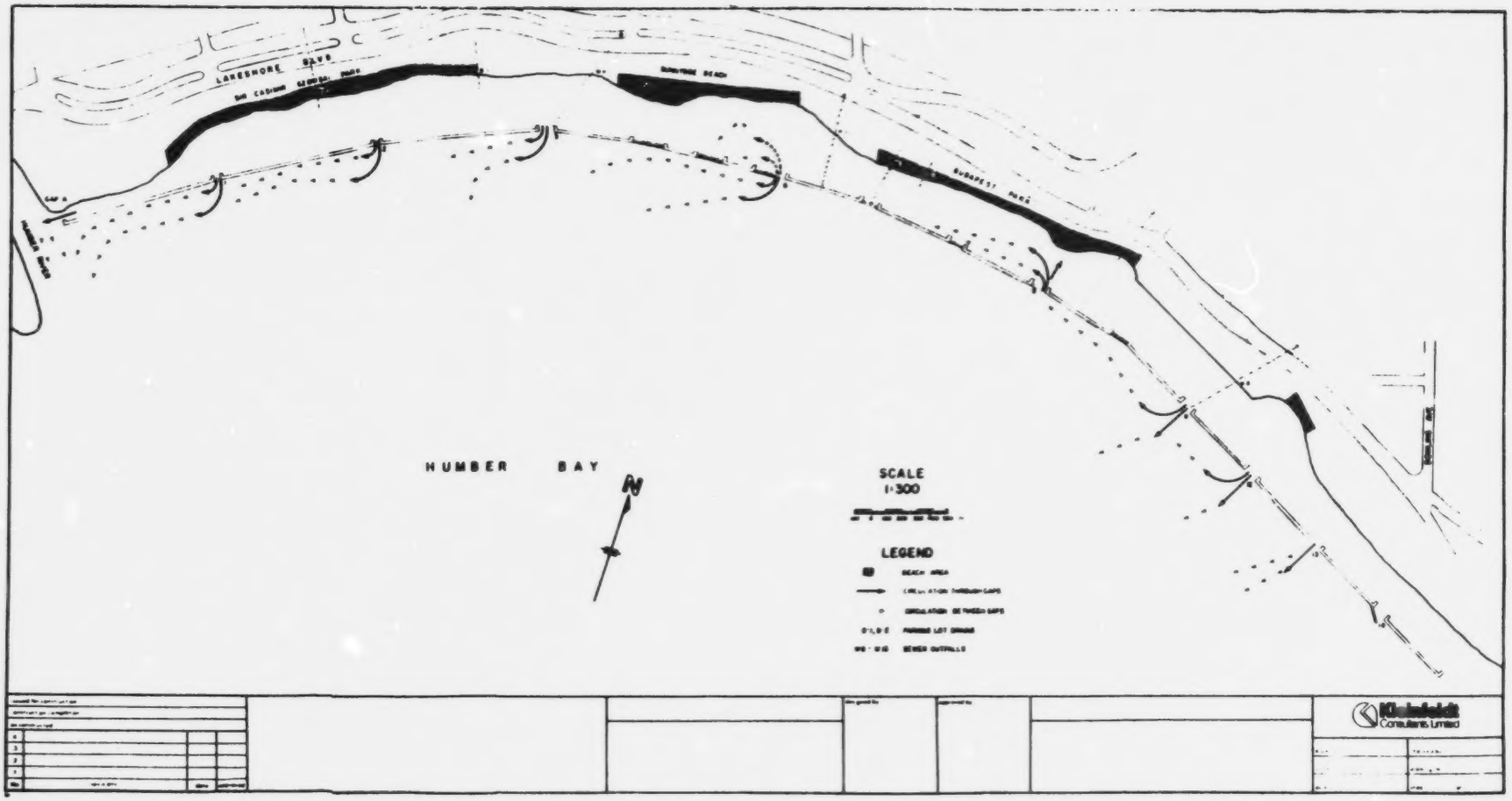


FIGURE 3.1.6 A
MOST PROBABLE CIRCULATION PATTERN UNDER NORTH WIND

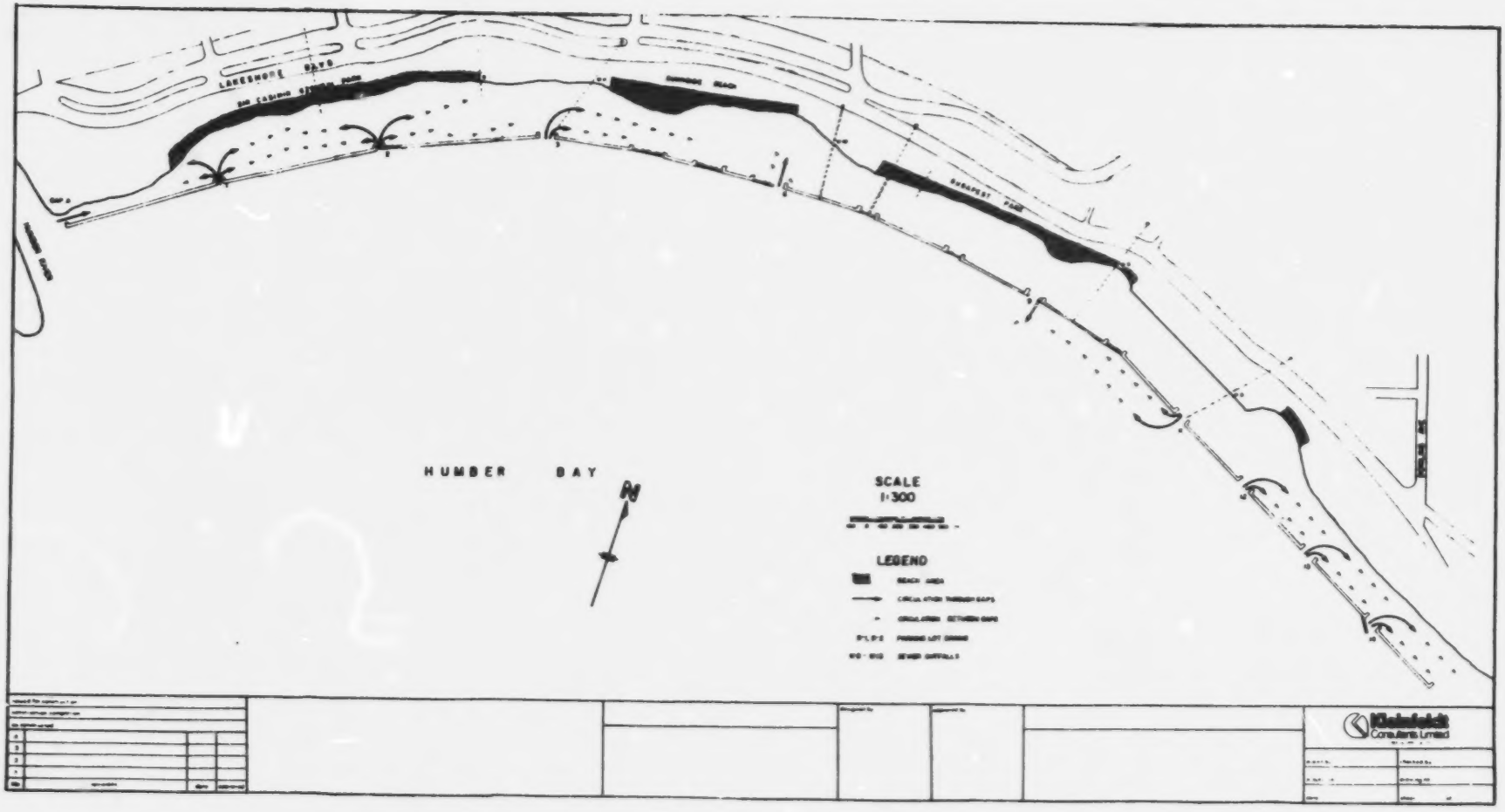


FIGURE 3.1.6 B
MOST PROBABLE CIRCULATION PATTERN UNDER SOUTH WIND

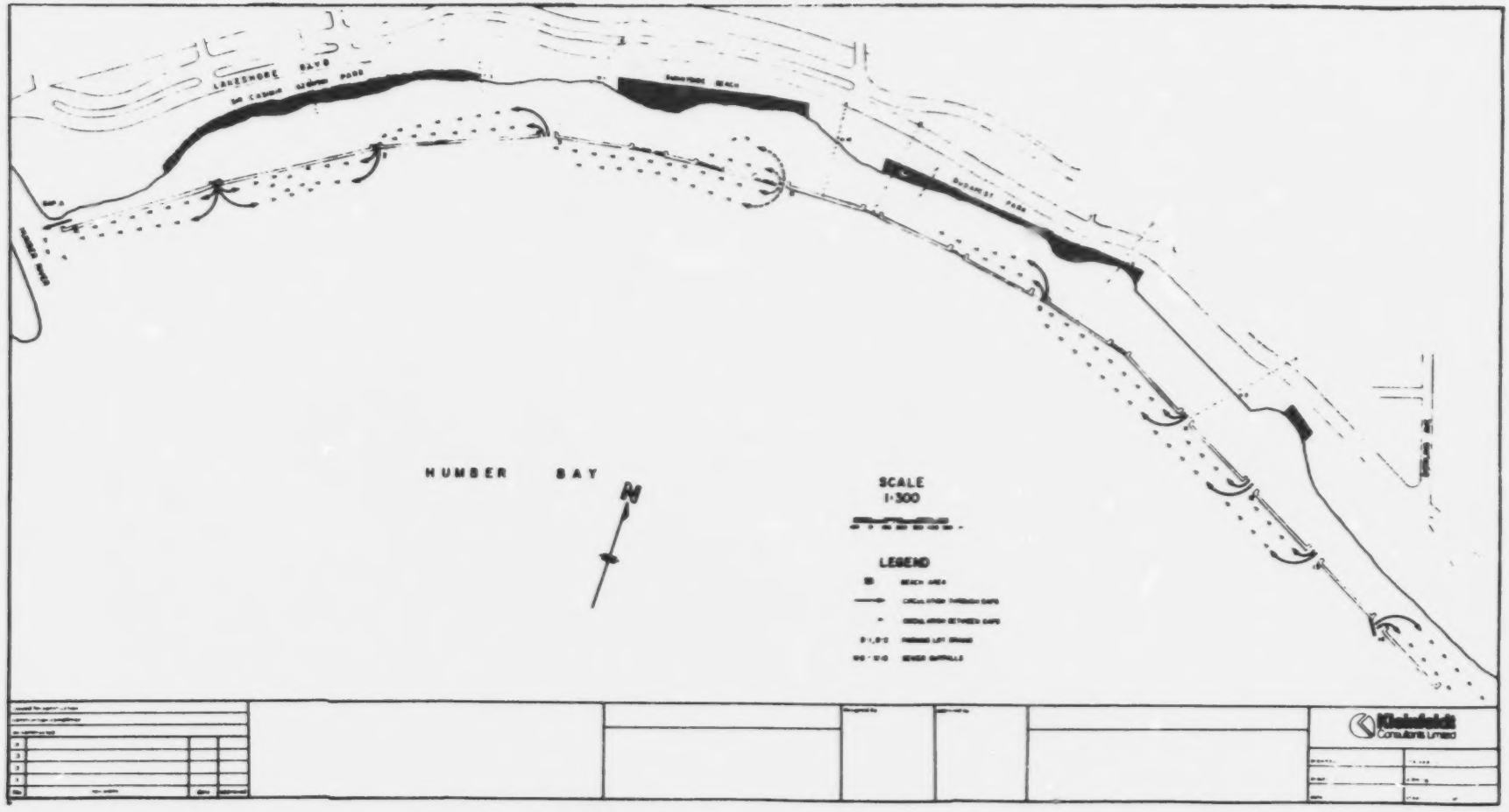


FIGURE 3.1.6 C
MOST PROBABLE CIRCULATION PATTERN UNDER EAST WIND

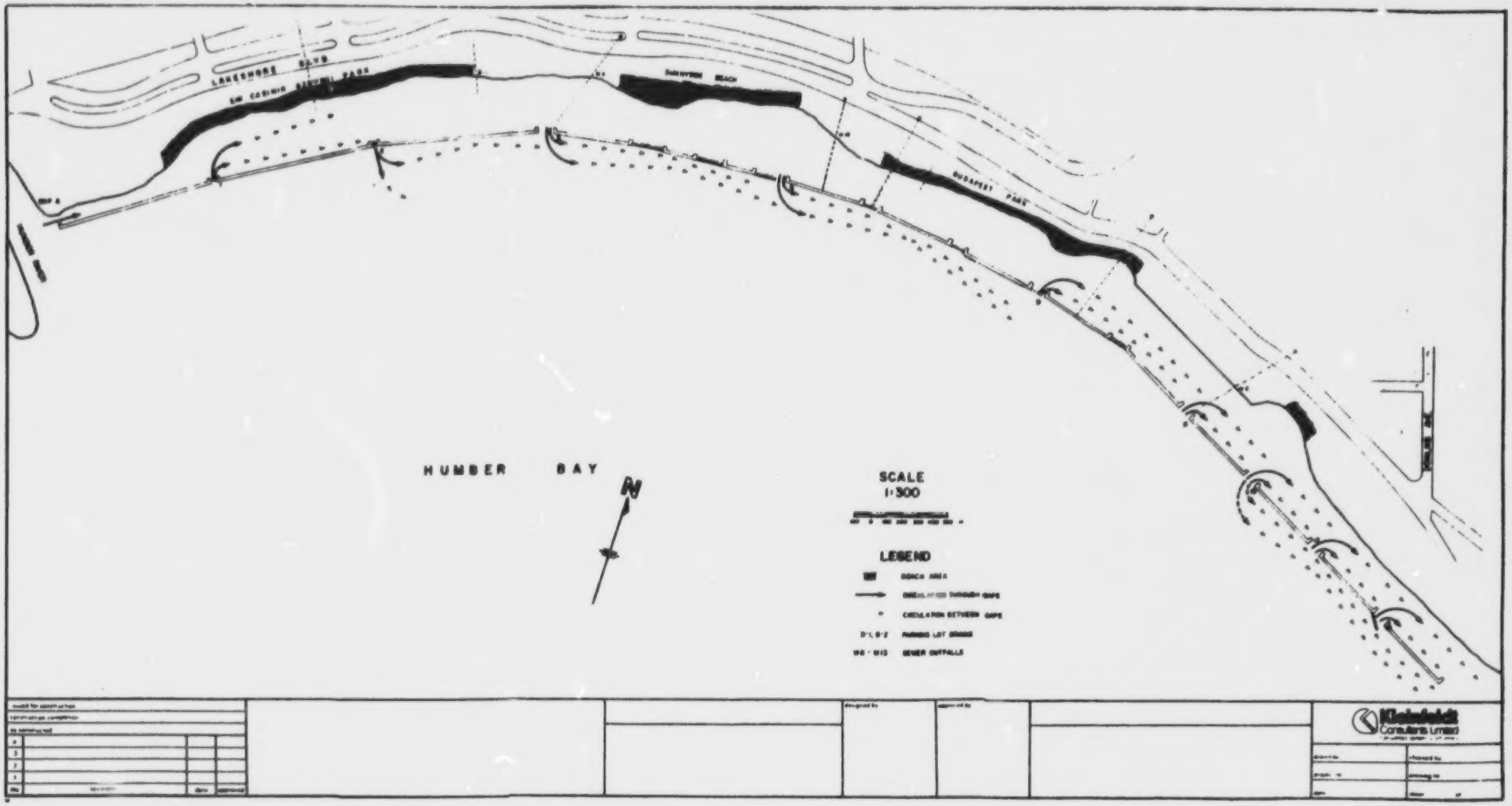


FIGURE 3.1.6 D

MOST PROBABLE CIRCULATION PATTERN UNDER WEST WIND

WESTERN BEACHES STUDY

VELOCITY VECTORS START TIME 85-6-12 0:0

TIME STEP 720 HOUR 8.000
EASTERLY FLOW
WIND 1. M/S FROM 270. THIS PLOT 85-6-12 8:0

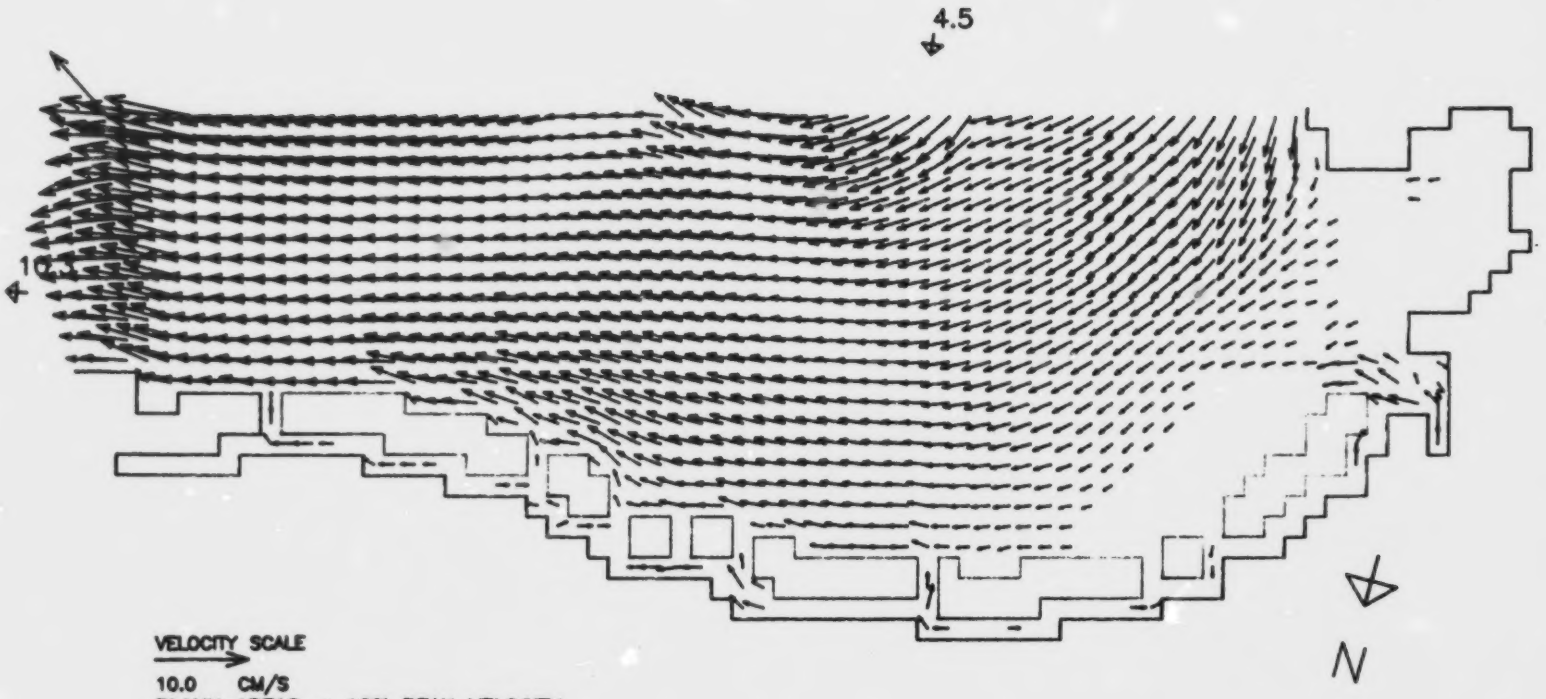


FIGURE 3.1.7 A - VELOCITY VECTORS

WESTERN BEACHES STUDY

VELOCITY VECTORS START TIME 85-6-12 0:0

TIME STEP 720 HOUR 8.000
WESTERLY FLOW
WIND 1. M/S FROM 90. THIS PLOT 85-6-12 8:0

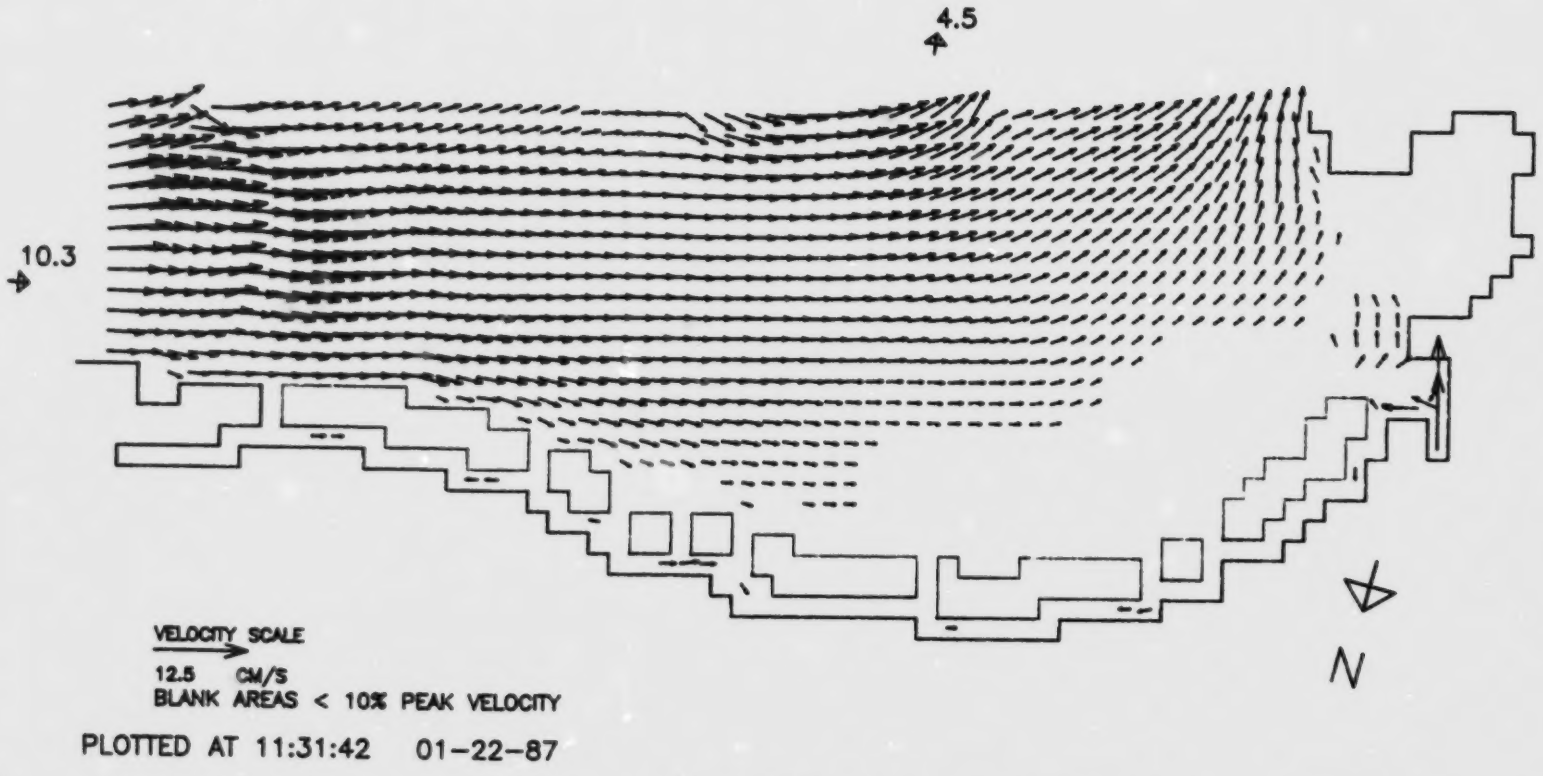
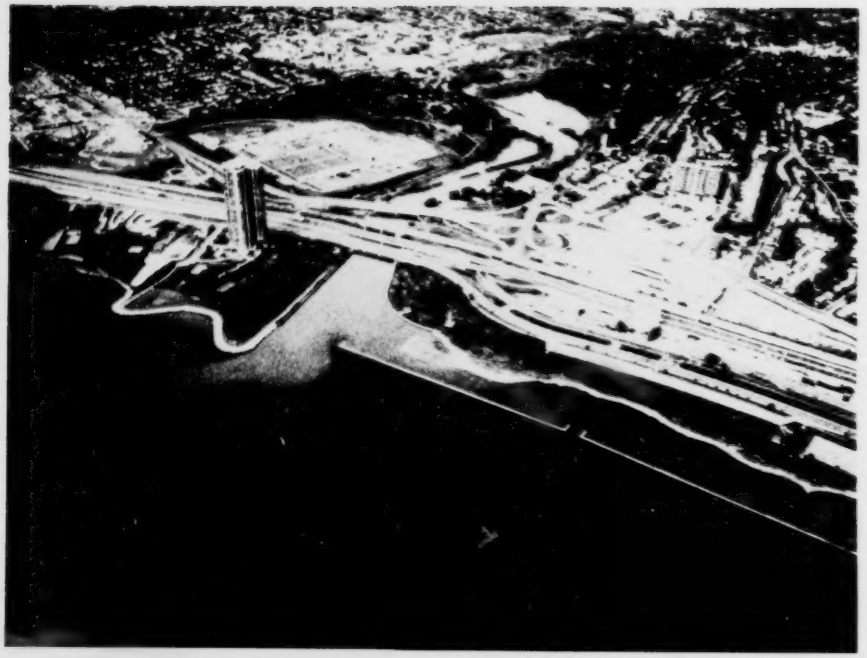
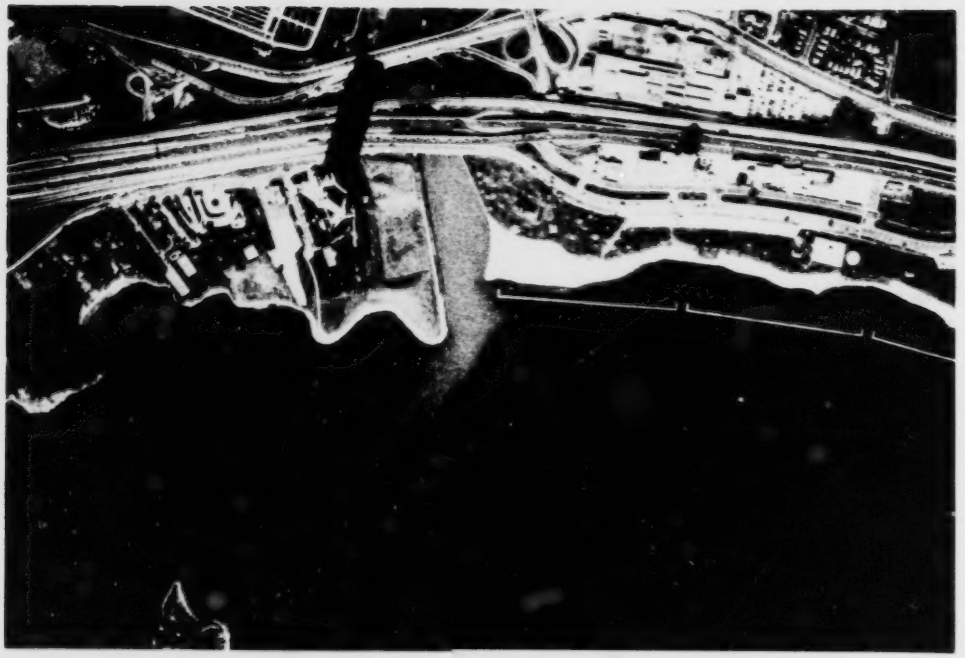


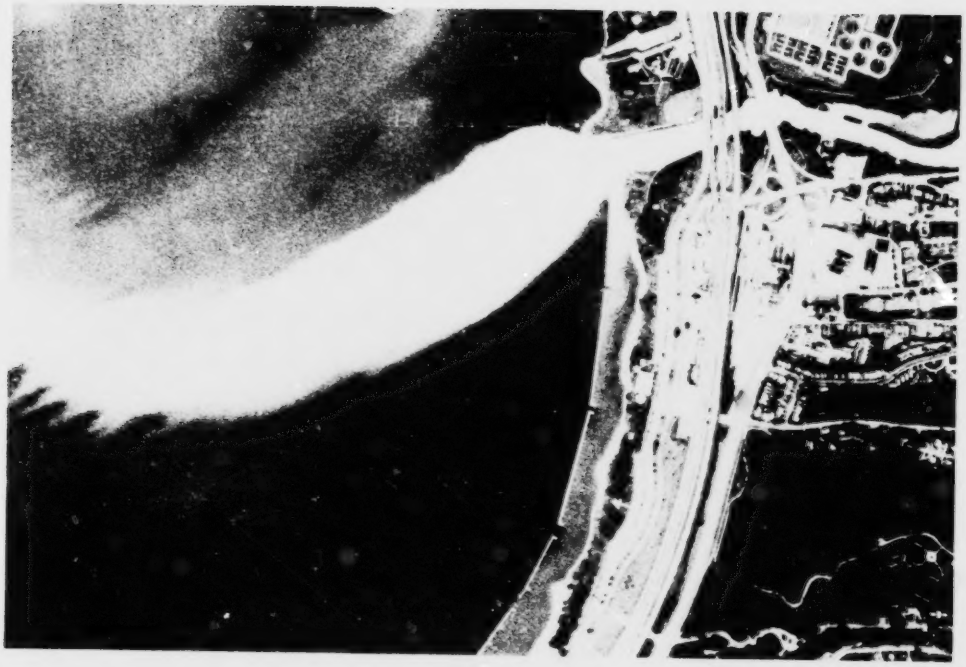
FIGURE 3.1.7 B - VELOCITY VECTORS



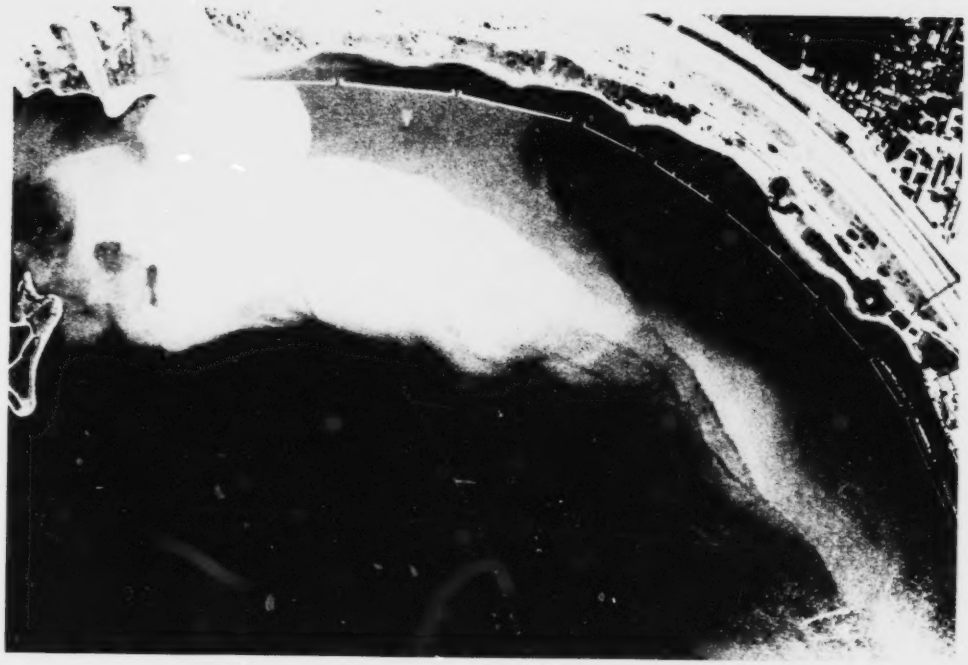
Humber River plume: Oct 18, 1983
Note its intrusion behind the
breakwall prior to the construction of
a deflecting jetty.



Humber River plume: Oct. 29, 1984
Note the newly constructed jetty on the east side of the river mouth which now deflects the river away from the beach area. The dark circular blob visible in the bottom left of the photograph is the plume from the Humber STP which is impinging on the Humber Bay waterfront area.



Humber River plume: 16 July, 1985
Runoff conditions coupled with strong
northerly winds have resulted in an
extensive plume on that day.



Humber River plume, 17 July, 1985
Note the dynamic nature of the
plume by comparing its configuration
with that photographed the previous day (above).

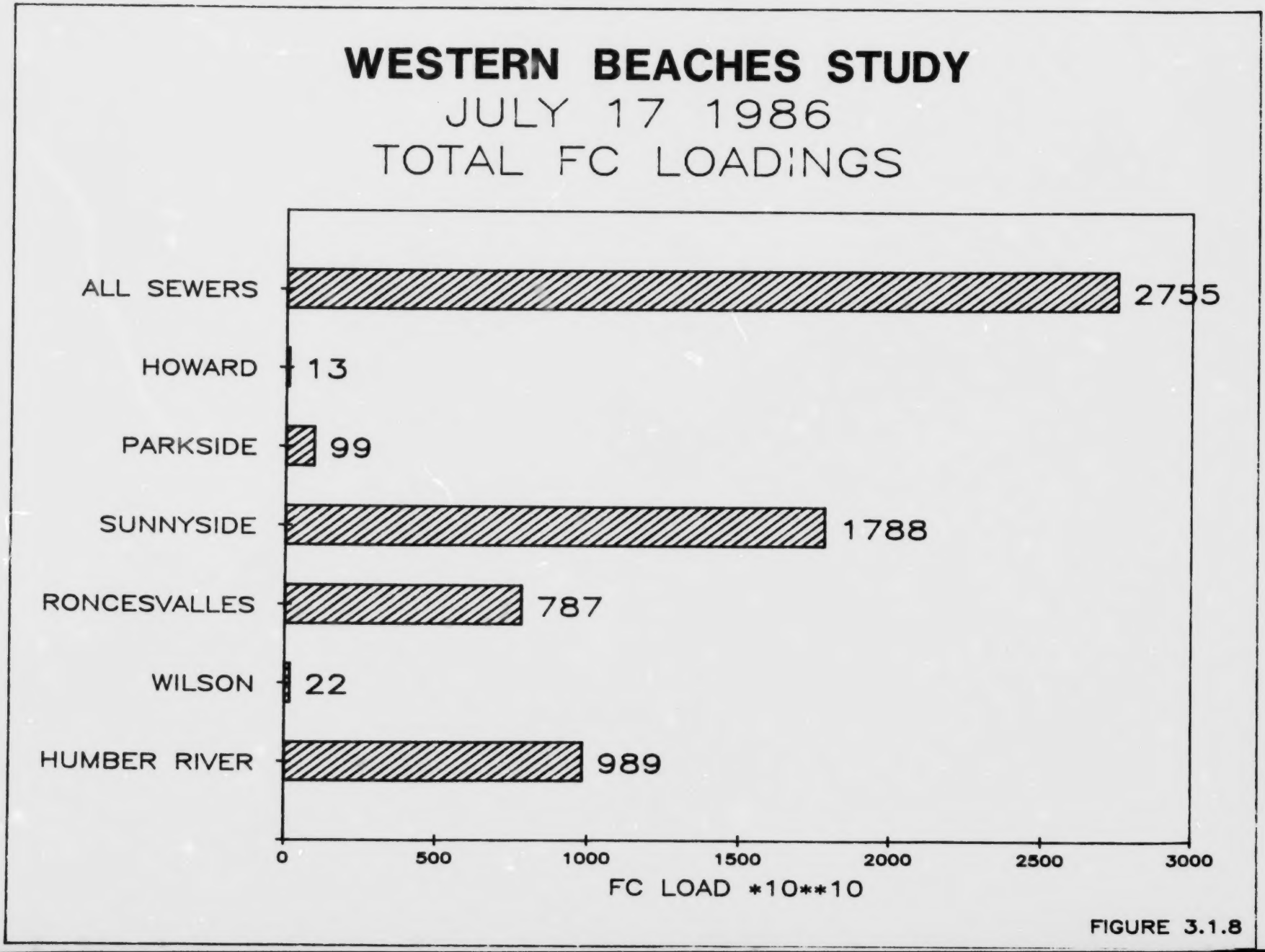

WESTERN BEACHES STUDY
JULY 17 1986
TOTAL FC LOADINGS
ALL SEWERS
2755
HOWARD
13
PARKSIDE
99
SUNNYSIDE
1788
RONCESVALLES
787
WILSON
22
HUMBER RIVER
989
0
500
1000
1500
2000
2500
3000
FC LOAD *10**10

FIGURE 3.1.8

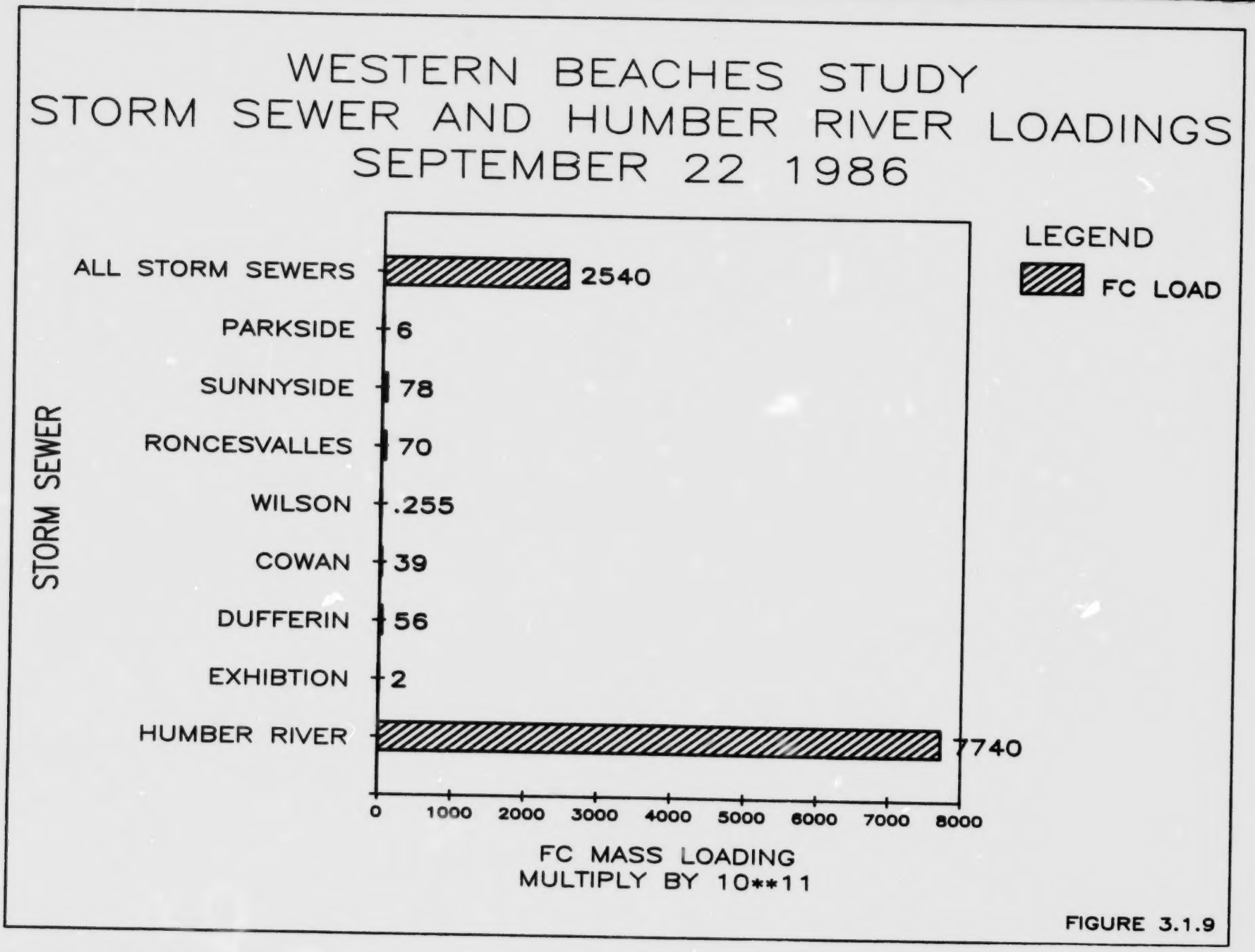

WESTERN BEACHES STUDY
STORM SEWER AND HUMBER RIVER LOADINGS
SEPTEMBER 22 1986
LEGEND
FC LOAD
STORM SEWER
ALL STORM SEWERS
PARKSIDE
SUNNYSIDE
RONCESVALLES
WILSON
COWAN
DUFFERIN
EXHIBTION
HUMBER RIVER
2540
6
78
70
.255
39
56
2
7740
0
1000
2000
3000
4000
5000
6000
7000
8000
FC MASS LOADING
MULTIPLY BY 10**11

FIGURE 3.1.9

3.2 WATER QUALITY

CHEMISTRY (NUTRIENTS)

Dry Weather Zonation

Humber Bay water quality can be divided into three general zones (Figure 3.2.1) as derived from cluster analysis of several conventional parameters (nutrients, turbidity, conductivity) sampled during dry weather conditions in 1983.

Zone 1: degraded area in the immediate vicinity of the Humber STP outfall as well as Mimico Creek and Humber River outlets;

Zone 2: intermediate, localized area of impact, less than 1 km wide, confined to the above major sources of imput;

Zone 3: offshore area.

Wet Weather Zonation

While during dry weather conditions, the zones of impact are restricted to the immediate vicinity of inputs, more extensive zones are evident following rain events. A wet weather survey conducted in September 1983 revealed a 0.5-1.0 km band of elevated phosphorus levels (greater than 20 µg/l) extending from Parkside Drive along the entire western Humber Bay shoreline (Figure 3.2.2) and covering approximately 25% of the Bay.

Eutrophication

Eutrophication is an increase in the input of nutrients (such as phosphorus) into a body of water with a resultant increase in biomass

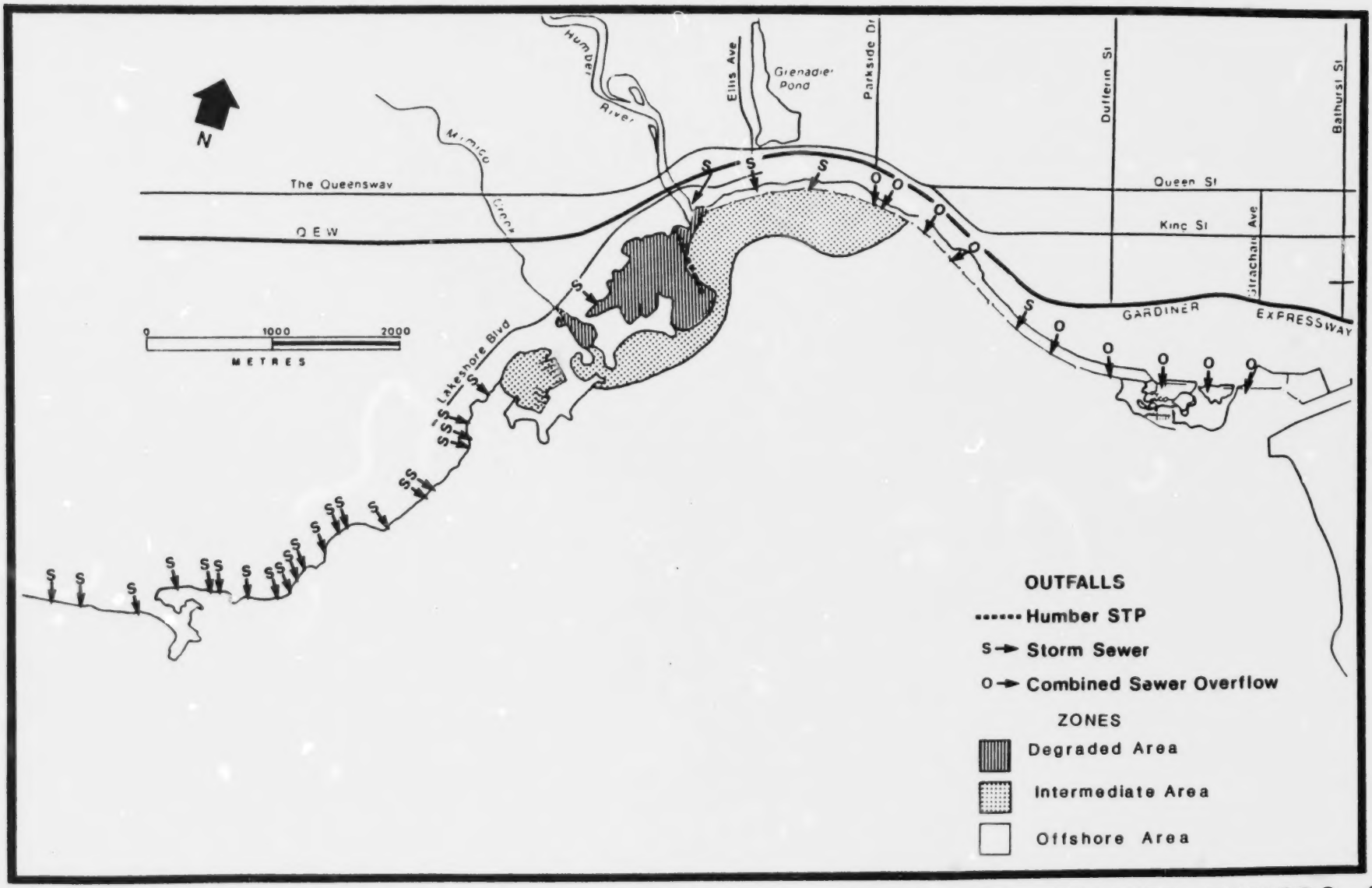


FIGURE 3.2.1 WATER QUALITY ZONES IN HUMBER BAY, DURING DRY WEATHER PERIODS, 1983

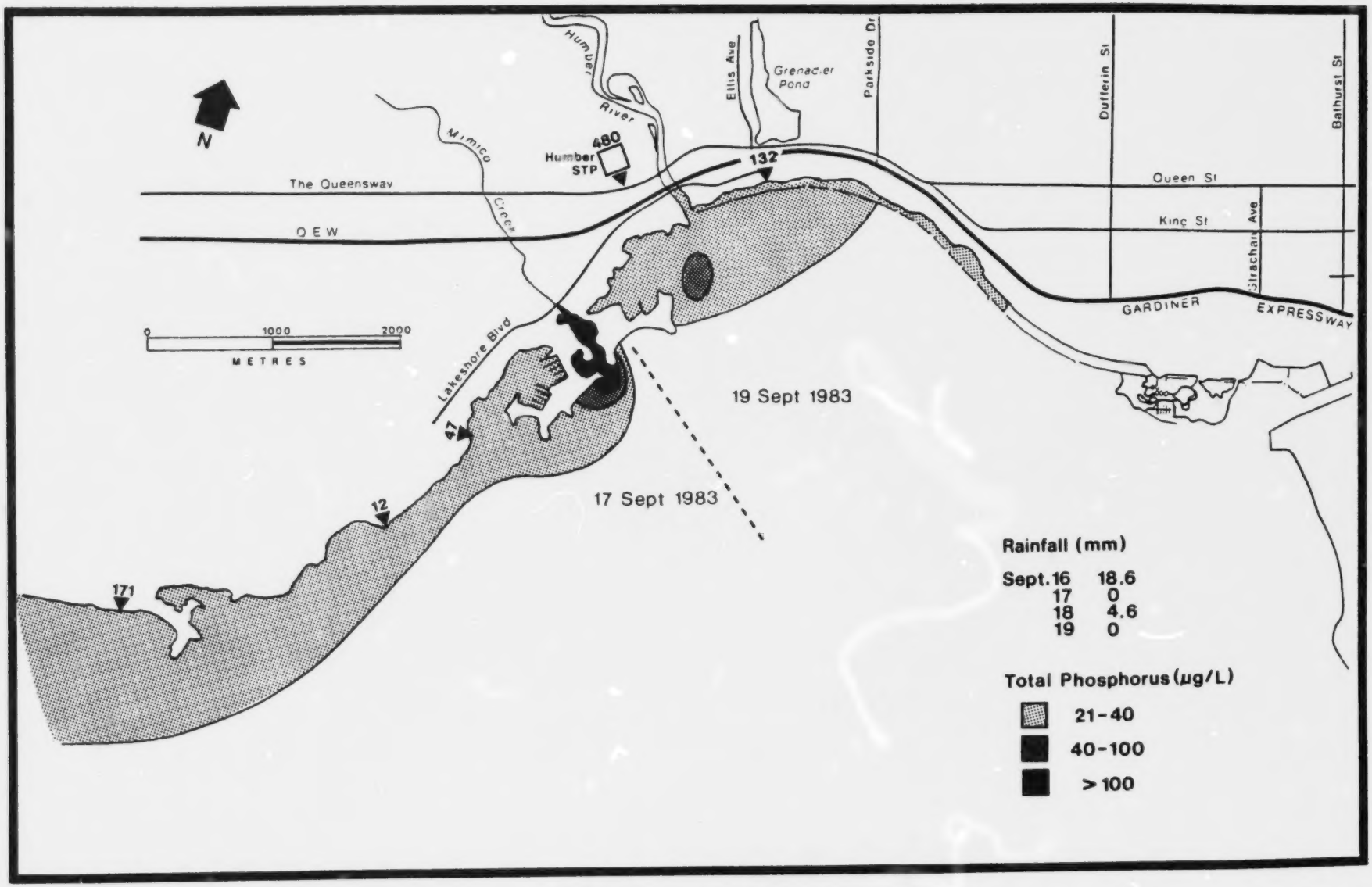


FIGURE 3.2.2 TOTAL PHOSPHORUS LEVELS FOLLOWING RAIN

(e.g. algae). In Humber Bay, elevated phosphorus levels, in combination with suitable substrate, are believed to be responsible for local growths of the nuisance alga Cladophora. To avoid nuisance concentrations of algae in lakes, it is suggested (MOE, 1984) that the average phosphorus concentration during the ice-free period should not generally exceed 20 µg/l. Sources of phosphorus to the area include Mimico Creek, Humber River, storm and combined overflow sewers and most importantly the Humber STP (presently almost in compliance with the 1 mg/l phosphorus effluent requirement). Recently, an algae skimmer has been used successfully by the City of Etobicoke for the removal of Cladophora within 3 feet of the shoreline.

BACTERIA

Bacterial contamination of Humber Bay beaches has received considerable attention since the summer of 1983 when the City of Toronto Department of Public Health posted the Western Beaches with "polluted waters" signs.

Criteria for Body Contact Recreation

Current Provincial bacteriological guidelines for swimming and bathing-use are based primarily on fecal coliforms. Incorporation of alternate indicators such as E. coli and Pseudomonas aeruginosa is presently under consideration. The U.S. Environmental Protection Agency (EPA 1986) and the International Joint Commission (IJC, 1983) have developed guidelines based on other bacterial indicators (summary provided below). Recent literature suggests that E. coli is a better indicator of the risk of swimming related illness in recreational waters then fecal coliform (Cabelli, 1983, Dufour, 1984).

Guidelines or Objectives for Swimming and Bathing

Indicator Bacteria (org./100 mls)

Agency	E. coli	P. aeruginosa
E.P.A.	126*	N/A
I.J.C.	23*	10**

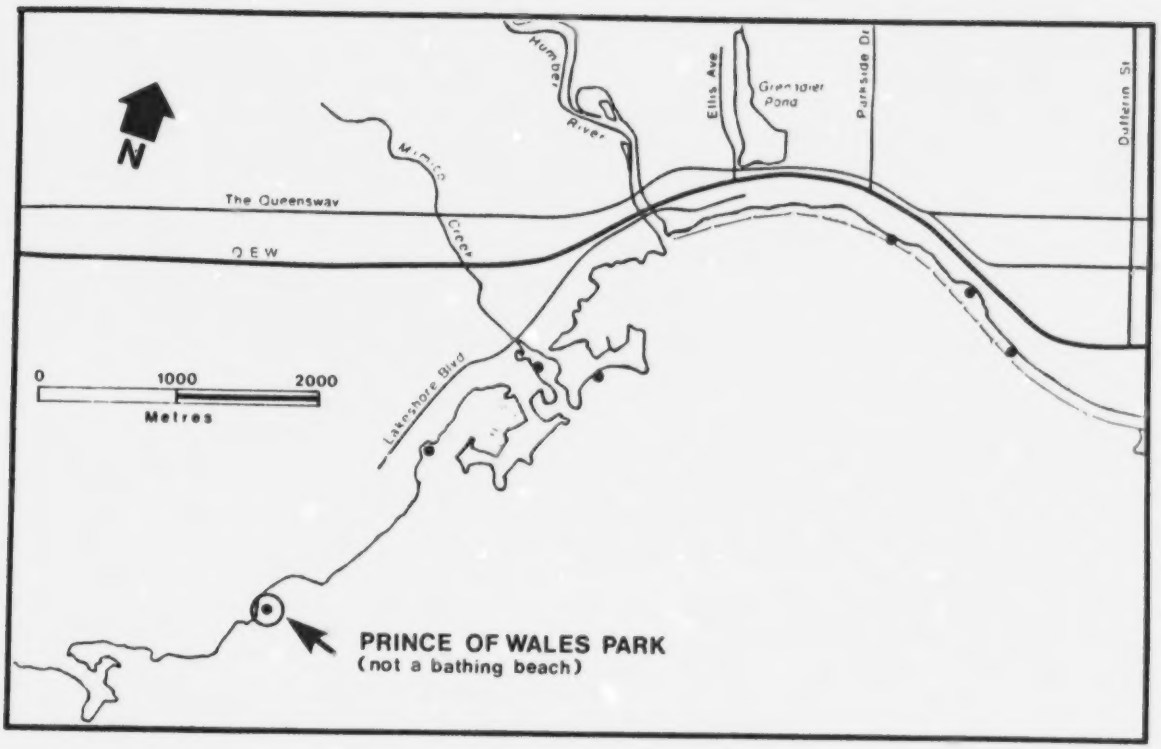
* based on geometric means
** no more than 25% of data should exceed this value.
NA not available.

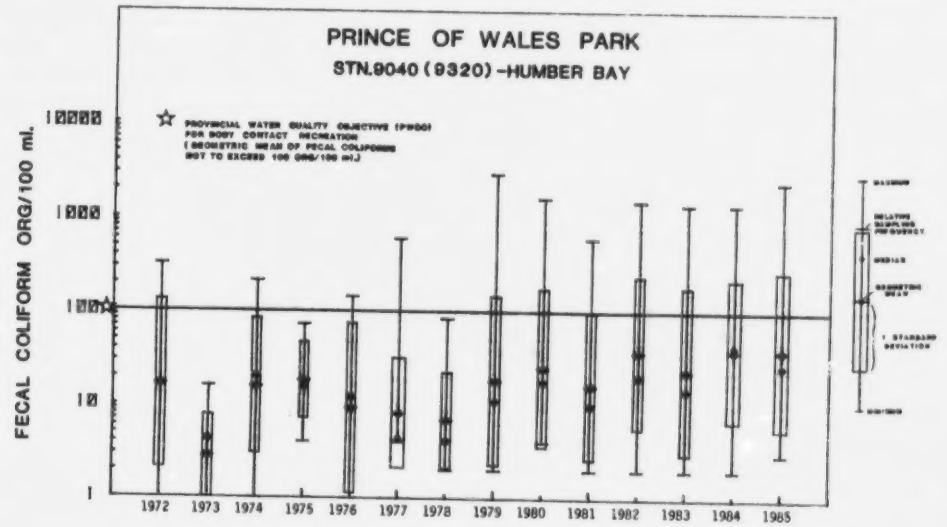
A 10 sample running geometric mean of fecal coliforms is presently used by Ontario health officials as part of the information to make decisions regarding beach postings. When this geometric mean exceeds 100 fecal coliforms per 100 mls of water, consideration is given to placarding a site. In addition, the determination of the risk of infection can be based on a number of other factors including a sanitary survey, epidemiological studies and the presence of pathogens.

Temporal Trends of Bacterial Levels in Humber Bay Nearshore

A historical summary of Department of Public Health monitoring results based on fecal coliforms is presented in Figures 3.2.3 - 3.2.9. Note that out of the 7 monitoring sites only 3 are swimming beaches (Amos Waites, Sunnyside Beach and Boulevard Club). For purposes of assessing the relative bacterial impairment across the Humber Bay waterfront, the summer geometric means at each beach location were compared to the body contact recreation guideline of 100 fecal coliforms/100 mls. Note that an absence of guideline violations based on summer geometric mean comparisons does not necessarily indicate safe swimming conditions at a site since such health related decisions are made on daily basis relying on running geometric means and other related factors previously discussed.

In the 1972-1985 period, the summer geometric mean of fecal coliforms at swimming beaches significantly exceeded the 100 organisms/100 ml guideline for body contact recreation at Amos Waites in 1982 and 1983 and at Sunnyside in 1982. Although summer geometric means above the 100 fecal coliforms/100 mls guideline were also noted in 1985 at Amos Waites Park Beach and in 1977, 1984 and 1985 at Sunnyside Beach, none

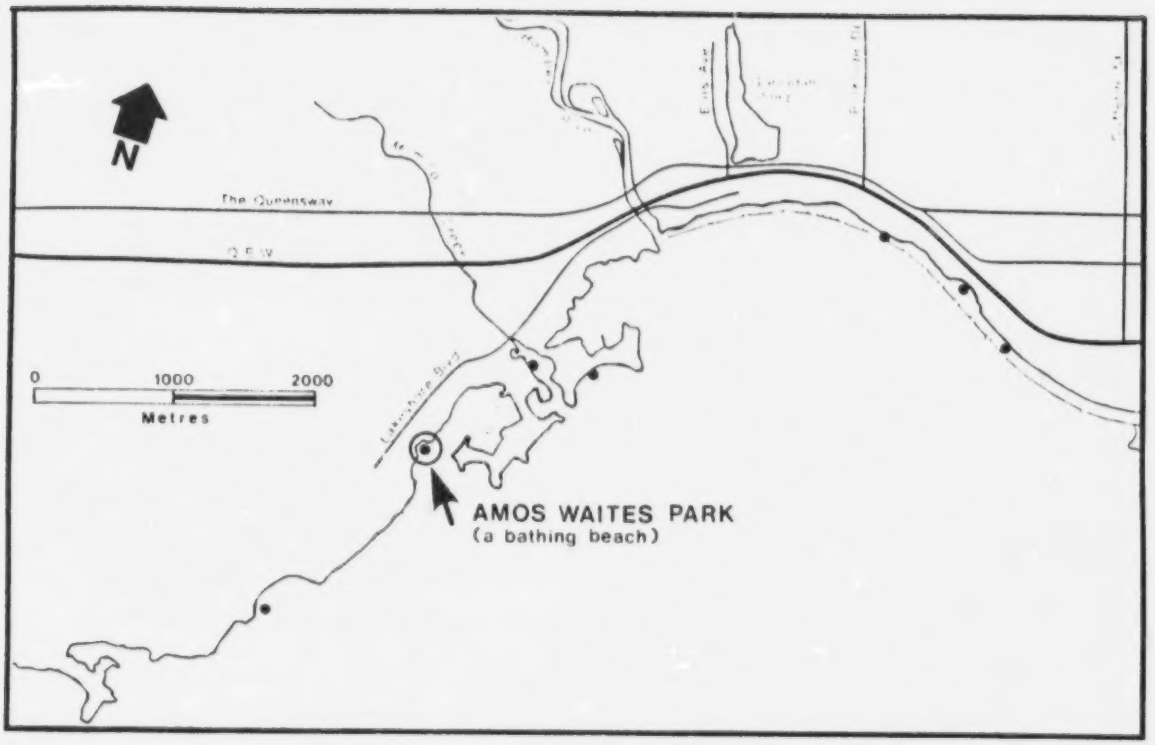


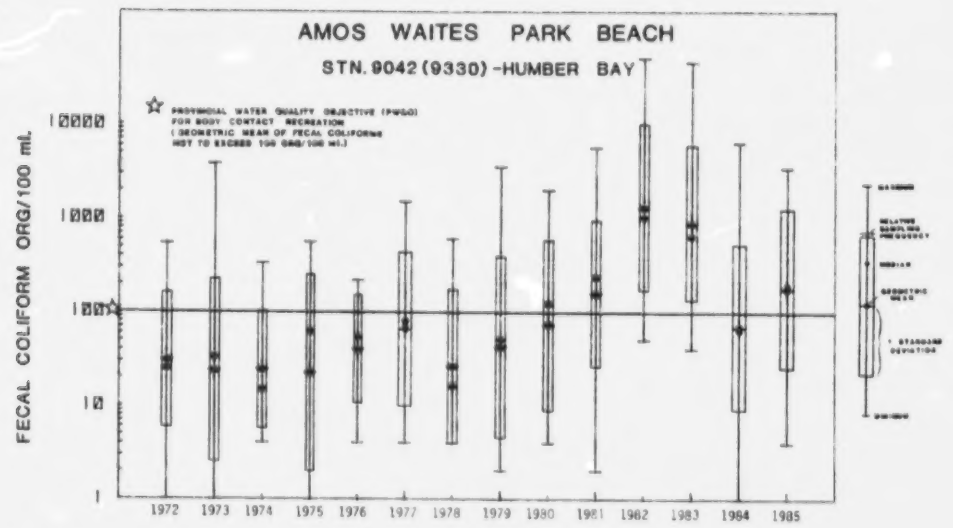


	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
N	15	16	13	12	13	29	16	16	16	15	15	17	18	30
Maximum	320	16	212	72	144	600	84	2900	244	110	600	1380	1380	2400
Minimum	1	1	1	4	1	4	2	2	4	2	8	2	4	3
Median	16	4	20	14	12	4	4	11	18	10	20	14	40	26
G. Mean	17	1	15	18	9	8	6	18	21	13	31	27	37	36
SD. Upper Limit	125	8	82	46	75	31	23	150	180	102	230	190	215	278
SD. Lower Limit	2	2	3	7	1	2	2	2	3	3	5	3	7	5

* Geometric mean significantly higher than PWQO (100 fecal coliforms/100 ml) at 95% confidence level.

FIGURE 3.2.3: HISTORICAL TRENDS (1972 - 1985) OF FECAL COLIFORM LEVELS AT PRINCE OF WALES PARK. (based on Dept. of Public Health Data)

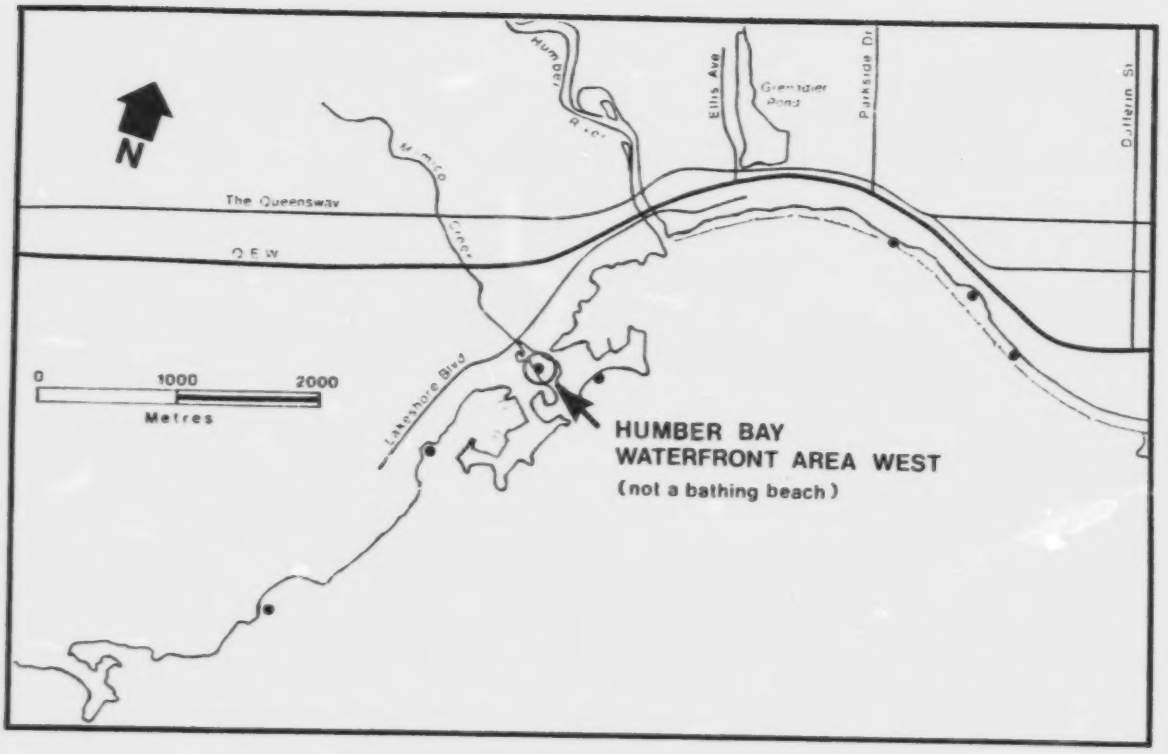


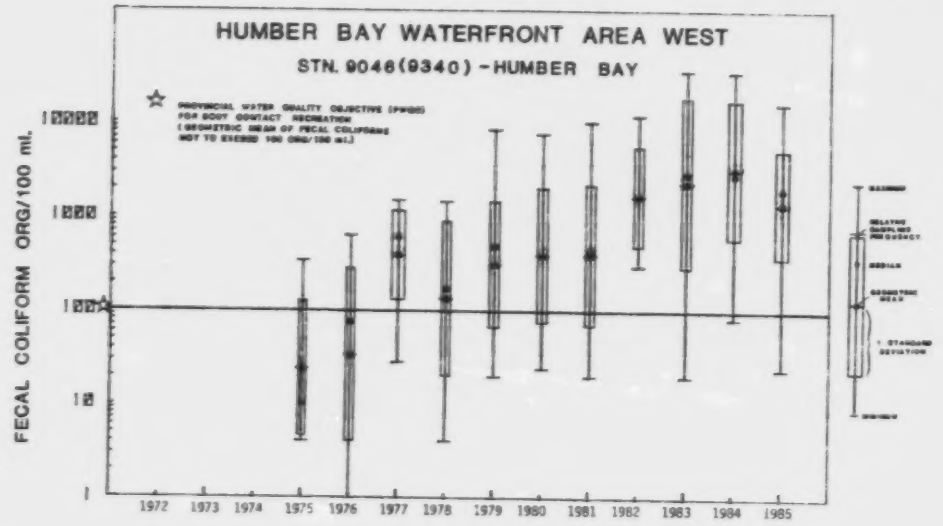


	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
N	15	15	13	10	10	28	15	15	16	14	15	20	29	30
Maximum	540	3800	330	560	216	1500	600	3500	1980	5600	100000	71000	6300	3400
Minimum	1	1	4	1	4	4	4	2	4	2	50	40	1	4
Median	24	32	18	60	52	76	16	48	116	218	1000	640	66	180
G. Mean	31	24	23	22	40	65	26	42	69	157	1134*	903*	68	173
SD. Upper Limit	168	220	104	258	212	438	180	390	590	920	9500	5900	515	1250
SD. Lower Limit	6	2	6	2	10	10	4	4	9	26	175	135	9	11

* Geometric mean significantly higher than PWQO (100 fecal coliforms/100 ml) at 95% confidence level.

FIGURE 3.2.4: HISTORICAL TRENDS (1972 - 1985) OF FECAL COLIFORM LEVELS AT AMOS WAITES PARK BEACH. (based on Dept. of Public Health Data)

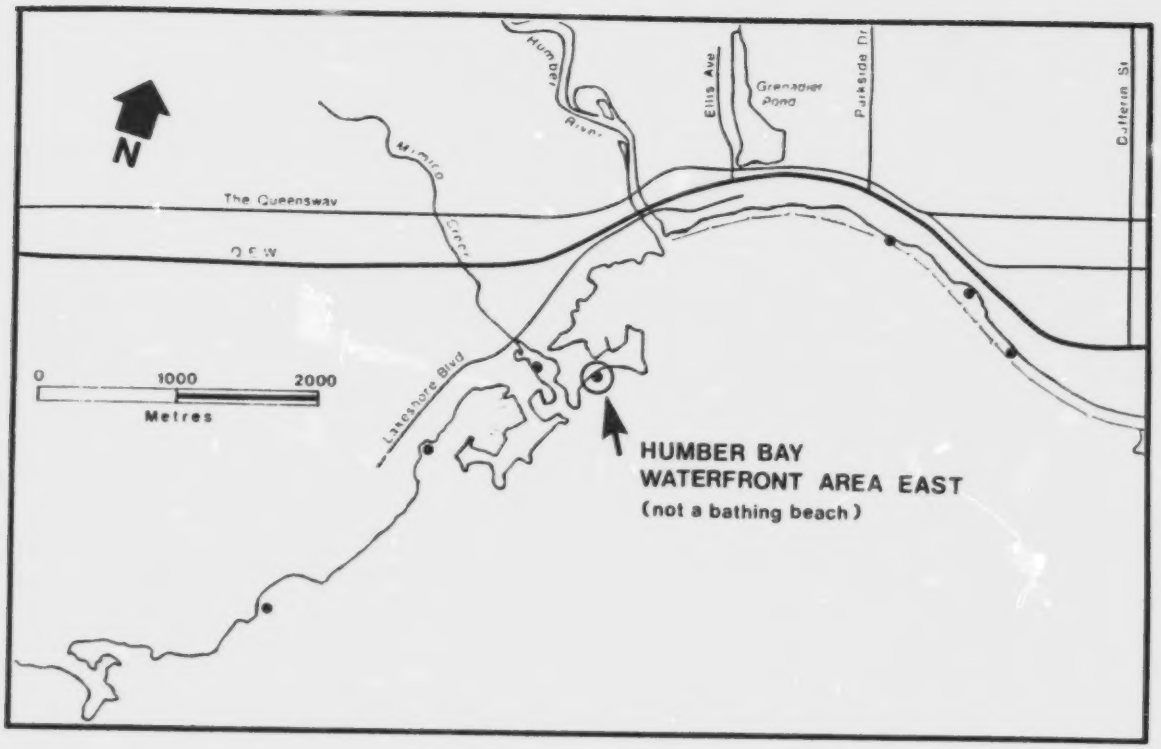


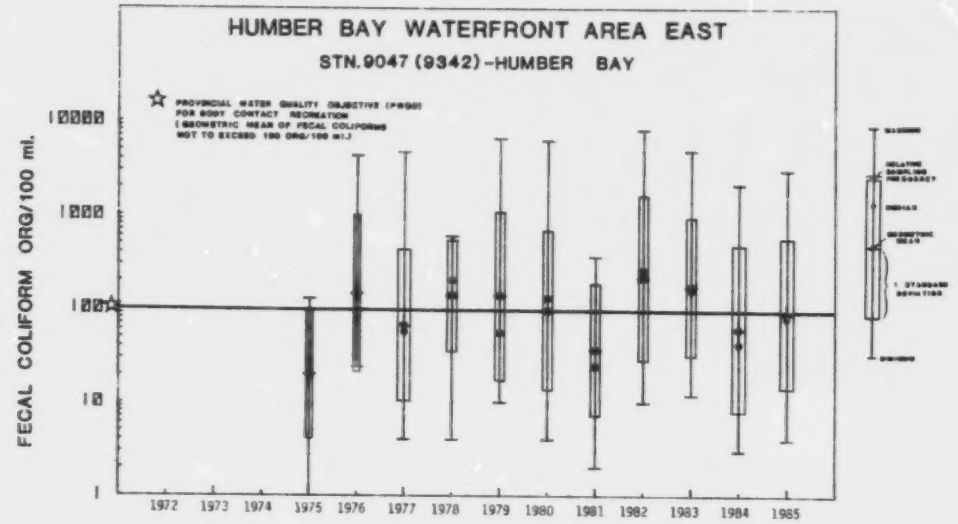


	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
N				8	11	27	12	15	16	15	14	15	28	30
Maximum				340	630	1500	1450	8500	7600	10200	18000	36000	1500000	16000
Minimum				4	1	28	4	20	24	40	300	20	82	240
Median				10	76	600	158	470	390	432	1630	2900	2900	1900
G. Mean				24	34	390*	135	313*	373*	376*	1699*	2627*	3652*	1598*
SD. Upper Limit				120	285	1250	890	1580	2000	2200	5500	19000	18000	5000
SD. Lower Limit				4	4	130	20	67	75	70	480	300	590	360

* Geometric mean significantly higher than PWQO (100 fecal coliforms/100 ml) at 95% confidence level.

FIGURE 3.2.5: HISTORICAL TRENDS (1972 - 1985) OF FECAL COLIFORM LEVELS AT HUMBER BAY WATERFRONT AREA WEST. (based on Dept. of Public Health Data)

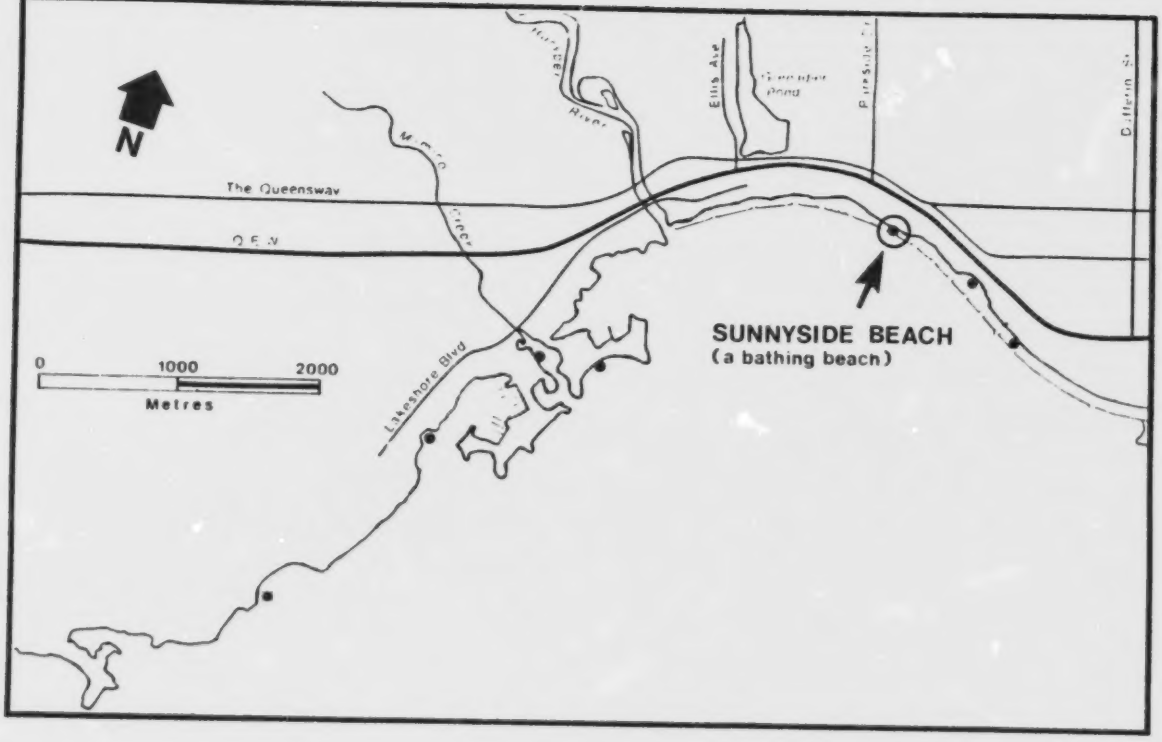


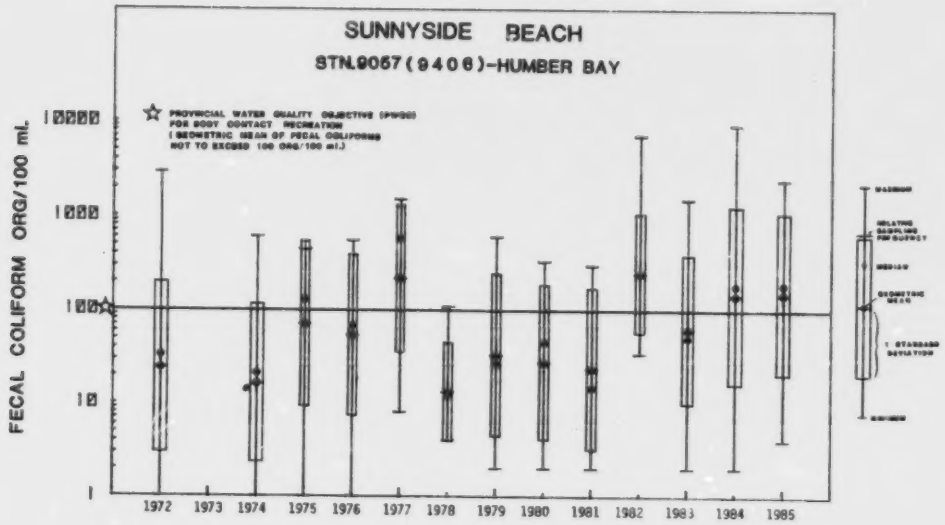


	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
N	7	7	27	15	15	15	15	14	15	29	30
Maximum	128	4300	4700	600	6500	6200	360	8000	4800	2120	3000
Minimum	1	24	4	4	10	12	8	10	12	3	4
Median	28	76	64	200	56	110	24	245	170	41	90
G. Mean	20	146	67	144	136	92	33	203	165	61	83
SD. Upper Limit	99	985	440	550	1100	675	190	1750	940	480	560
SD. Lower Limit	4	20	10	35	18	13	7	29	31	8	14

* Geometric mean significantly higher than PWQO (100 fecal coliforms/100 ml) at 95% confidence level.

FIGURE 3.2.6: HISTORICAL TRENDS (1972 - 1985) OF FECAL COLIFORM LEVELS AT HUMBER BAY WATERFRONT AREA EAST. (based on Dept. of Public Health Data)

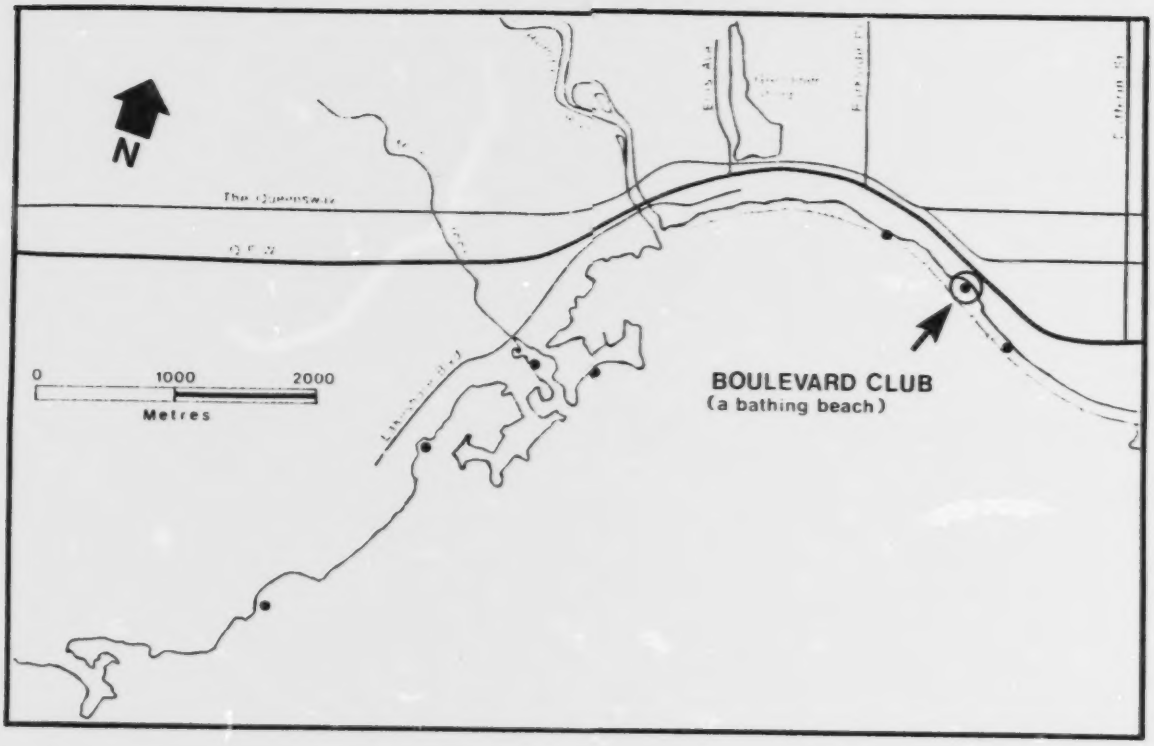


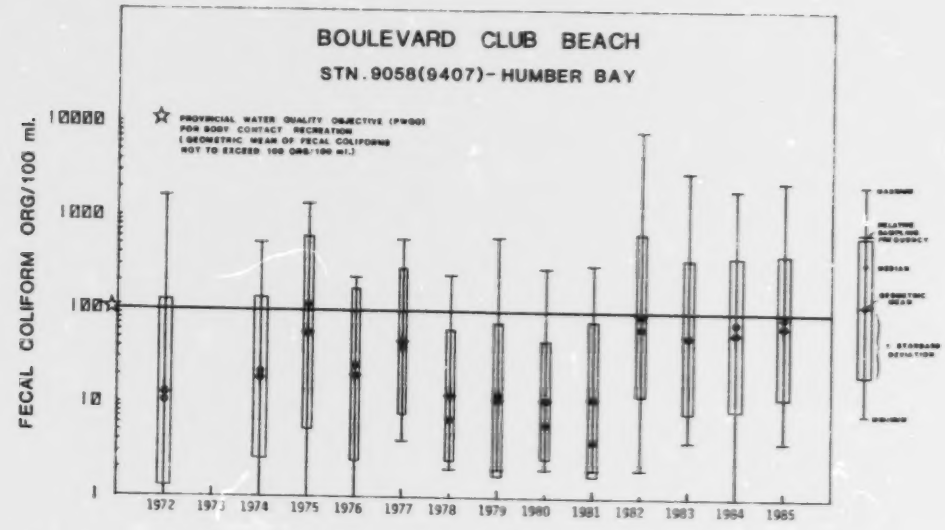


N	29	27	12	11	11	12	14	14	16	15	21	30	28
Maximum	2900	600	440	544	1500	108	600	328	272	7100	990	9100	2400
Minimum	1	1	1	1	8	4	2	8	2	34	8	2	4
Median	32	20	128	64	590	12	28	44	15	252	50	184	180
G. Mean	24	16	70	53	215	14	33	32	28	254*	56	142	148
SD. Upper Limit	200	115	520	390	1300	46	245	188	175	1080	390	1250	1030
SD. Lower Limit	3	2	9	7	35	4	4	4	3	60	10	17	20

* Geometric mean significantly higher than PWQO (100 fecal coliforms/100 ml) at 95% confidence level.

FIGURE 3.2.7: HISTORICAL TRENDS (1972 - 1985) OF FECAL COLIFORM LEVELS AT SUNNYSIDE BEACH. (based on Dept. of Public Health Data)

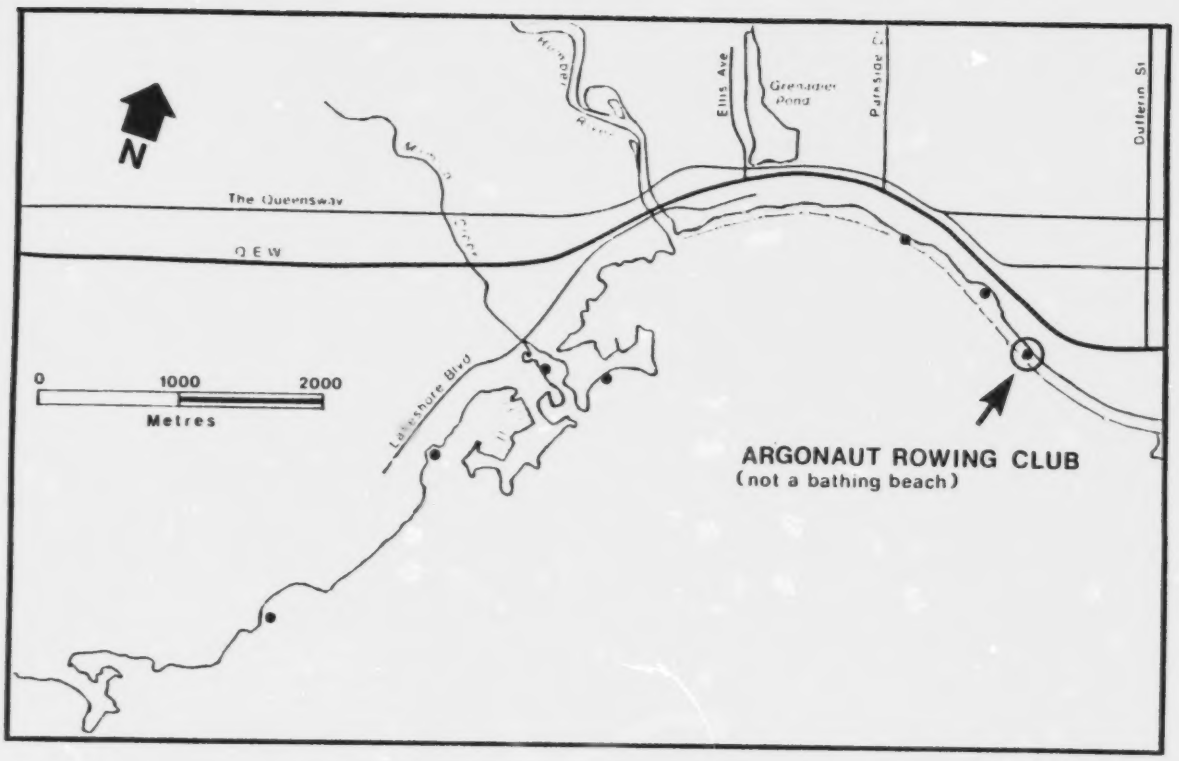


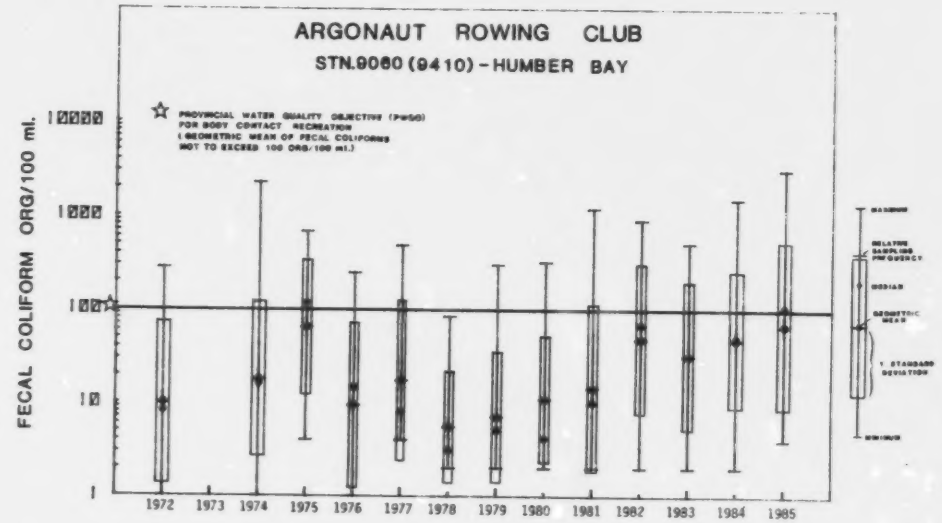


N	29	30	14	11	10	12	14	14	16	15	20	30	28
Maximum	1640	520	1360	224	564	236	600	280	304	8100	1500	1960	2400
Minimum	1	1	1	1	4	2	2	4	2	10	4	1	4
Median	10	20	105	24	42	7	12	6	4	64	51	77	84
G. Mean	13	19	57	20	46	12	11	12	13	84	51	57	68
SD. Upper Limit	130	135	600	175	283	162	74	48	77	670	340	385	400
SD. Lower Limit	1	3	5	2	8	2	2	3	2	12	8	9	12

* Geometric mean significantly higher than PWQO (100 fecal coliforms/100 ml) at 95% confidence level.

FIGURE3.2.8:HISTORICAL TRENDS (1972 - 1985) OF FECAL COLIFORM LEVELS AT BOULEVARD CLUB BEACH. (based on Dept. of Public Health Data)




ARGONAUT ROWING CLUB
STN.9060 (9410) - HUMBER BAY
PROVINCIAL WATER QUALITY OBJECTIVE (PWQO) FOR BODY CONTACT RECREATION (GEOMETRIC MEAN OF FECAL COLIFORMS NOT TO EXCEED 100 ORG/100 ml.)
FECAL COLIFORM ORG/100 ml.
10000
1000
100
10
1
1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
N	29		28	14	11	10	12	14	14	16	15	17	30	28
Maximum	276		2240	670	244	480	84	300	320	1190	900	510	700	3100
Minimum	1		1	4	1	4	2	2	4	8	2	2	2	4
Median	8		18	112	16	8	3	5	4	10	70	32	46	102
G. Mean	10		18	64	9	17	5	7	12	17	47	29	47	64
SD. Lower Limit	73		120	344	73	135	21	36	53	112	306	194	263	520
SD. Upper Limit	1		3	13	1	2	1	1	2	2	8	5	9	9

* Geometric mean significantly higher than PWQO (100 fecal coliforms/100 ml) at 95% confidence level.

FIGURE3.2.9:HISTORICAL TRENDS (1972 - 1985) OF FECAL COLIFORM LEVELS AT ARGONAUT ROWING CLUB. (based on Dept. of Public Health Data)

were statistically higher than the guideline because of the high natural variability inherent in the data set.

Fecal coliform numbers significantly in excess of the guideline were also recorded at a non-swimming location of Humber Bay Waterfront Area West in 1977 and during the 1979-1985 period. Prior to 1977, fecal coliform levels at that location were low but increased dramatically since the completion of the Humber Bay Waterfront Area lakefills. No distinct temporal trends were apparent at the other sites.

Effect of Weather on Bacterial Levels in Humber Bay Nearshore

The extent of bacterial contamination in Humber Bay during a rain event in September 1983 is illustrated in Figure 3.2.10A. This scenario shows plumes containing elevated numbers of fecal coliforms hugging the shoreline west of the Humber River along a 0.5-1.0km band and intruding behind the breakwall along the entire length of the Western Beaches. Note that this observation was made before the construction of a deflecting jetty. Although intrusions of Humber River water still occur, they are now less frequent then before the jetty construction.

In order to evaluate the differences between dry-weather and wet-wether effects on bacterial levels in the nearshore zone, the most recent (1985) data were divided into dry-weather and all-weather data sets. Specifically, the 1985 Health Department data for each monitoring site were used to derive a 10 day running geometric mean based on the dry weather data as well as on the entire data set (wet and dry days) (Figures 3.2.10-3.2.16.) A data point was classified as dry if rainfall on the day of sampling and in the 48 hours preceeding did not exceed 0.5 cm.

A comparison of dry-weather vs. all-weather running geometric means at locations west of the Humber River shows only small differences between them indicating that local storm sewer runoff and wet-weather discharge from Mimico Creek may have only a minor effect on bacterial levels at these sites. On the other hand, the small size of the data set used may bias this conclusion. Limited data collected by MOE in Mimico Creek, for instance, have shown a district difference between dry weather and wet weather coliform levels. (Table 5.1.1).

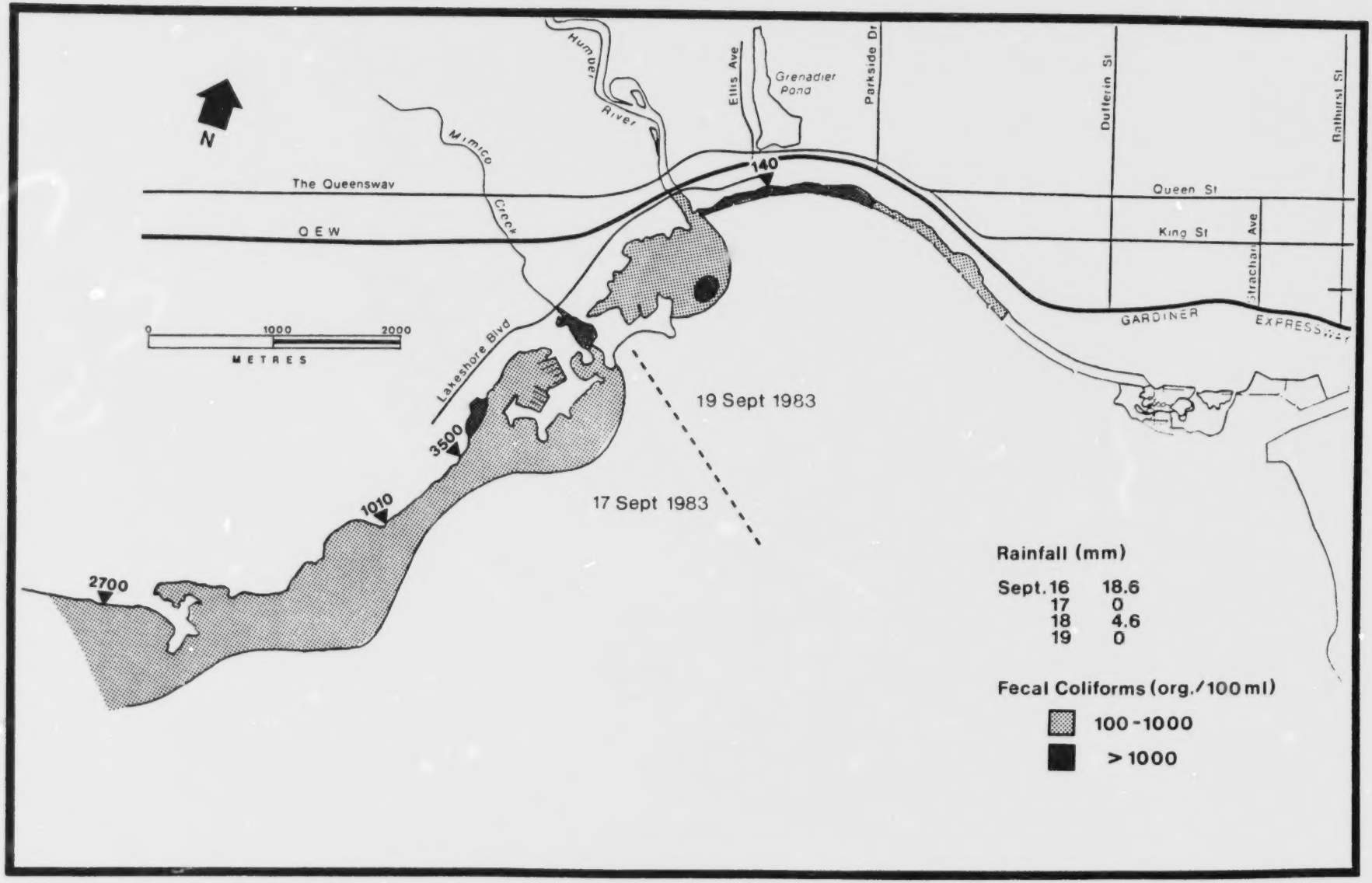
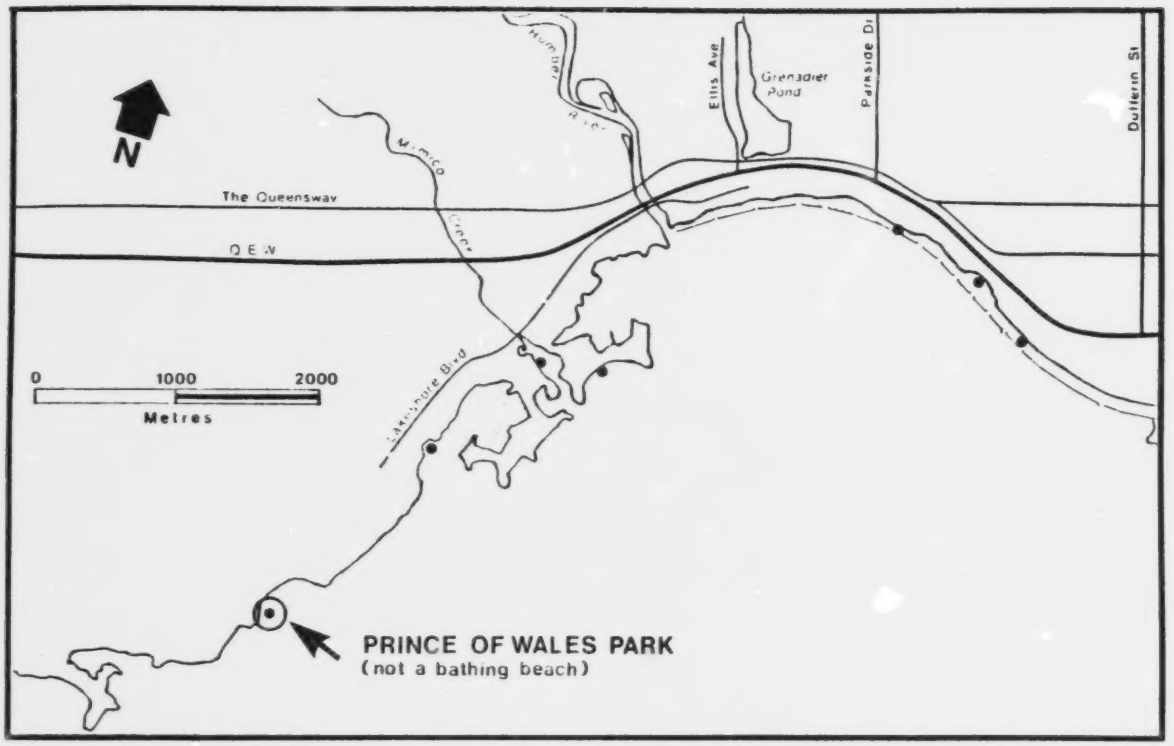


FIGURE 3.2.10A FECAL COLIFORM LEVELS FOLLOWING RAIN



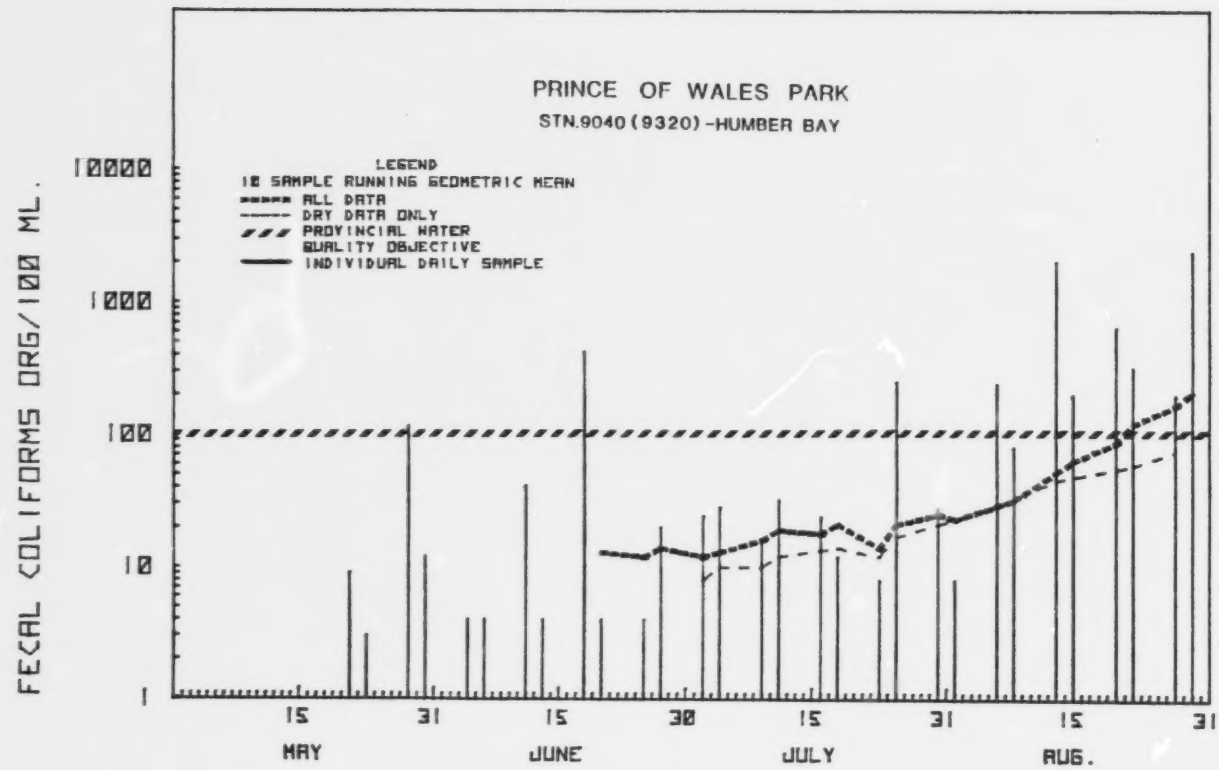
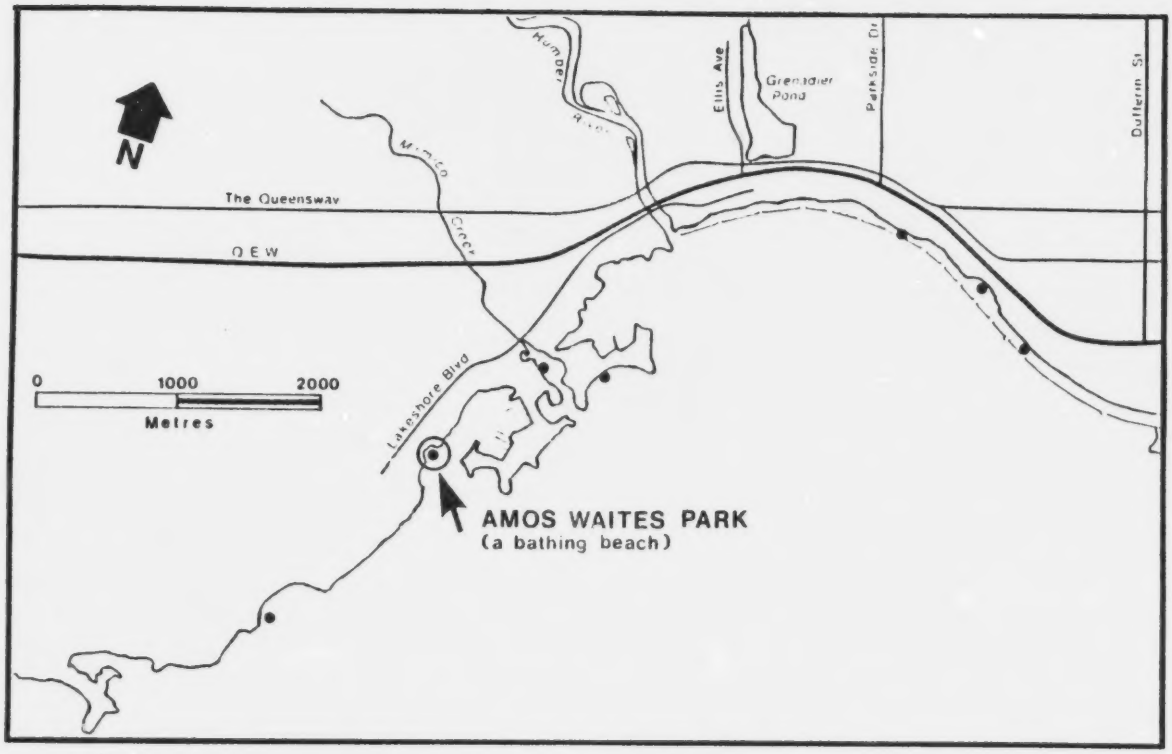


FIGURE 3.2.10: TEMPORAL TRENDS IN FECAL COLIFORM DENSITIES AND THE EFFECT OF THE WET WEATHER FLOW ON THE RUNNING GEOMETRIC MEAN, HUMBER BAY - 1985.



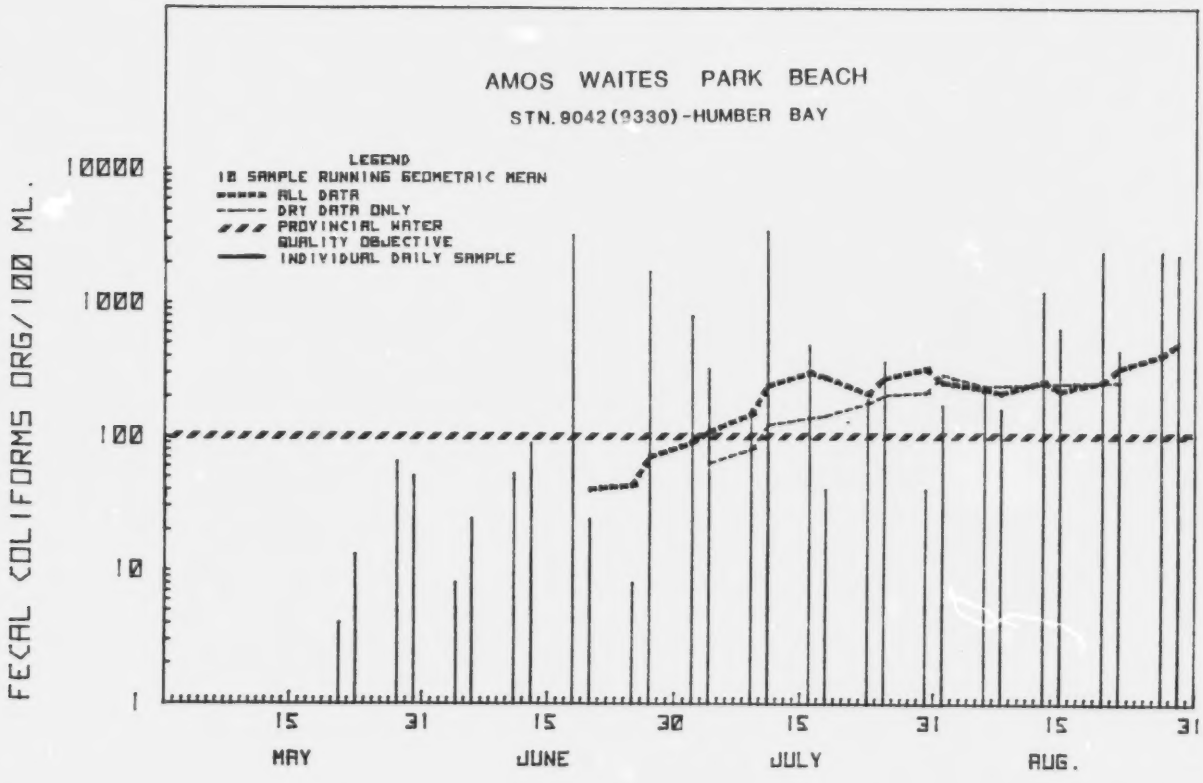
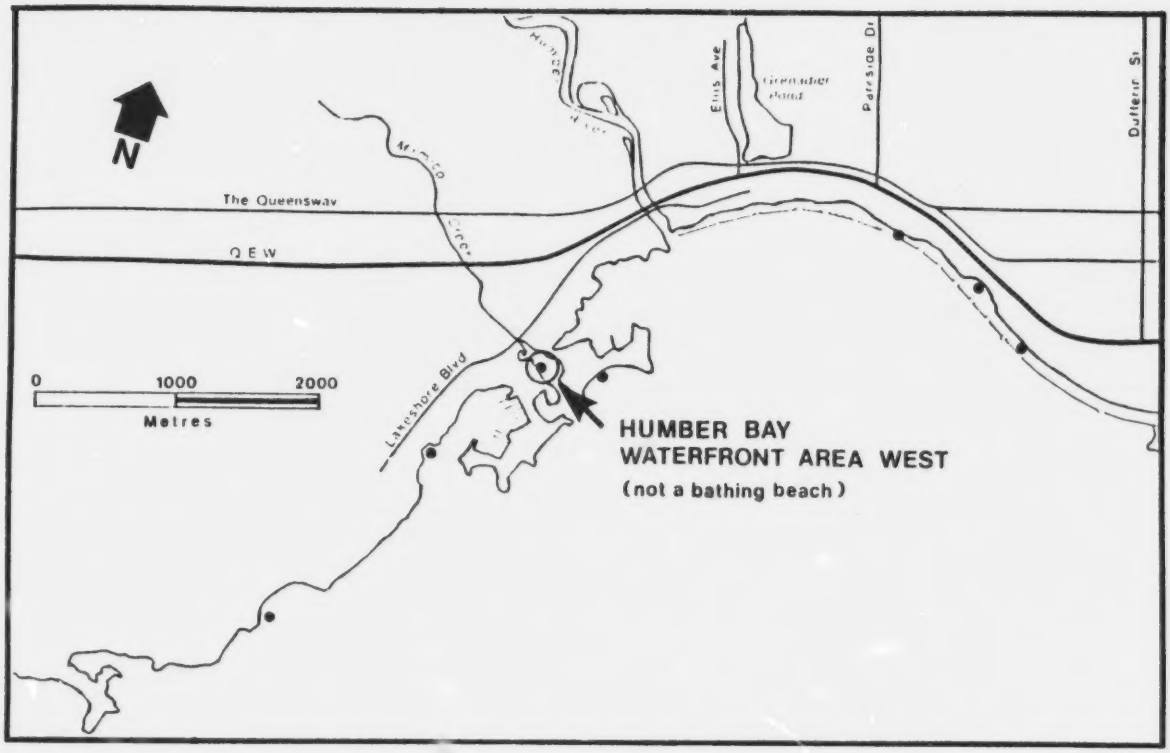


FIGURE 3.2.11: TEMPORAL TRENDS IN FECAL COLIFORM DENSITIES AND THE EFFECT OF THE WET WEATHER FLOW ON THE RUNNING GEOMETRIC MEAN, HUMBER BAY - 1985.



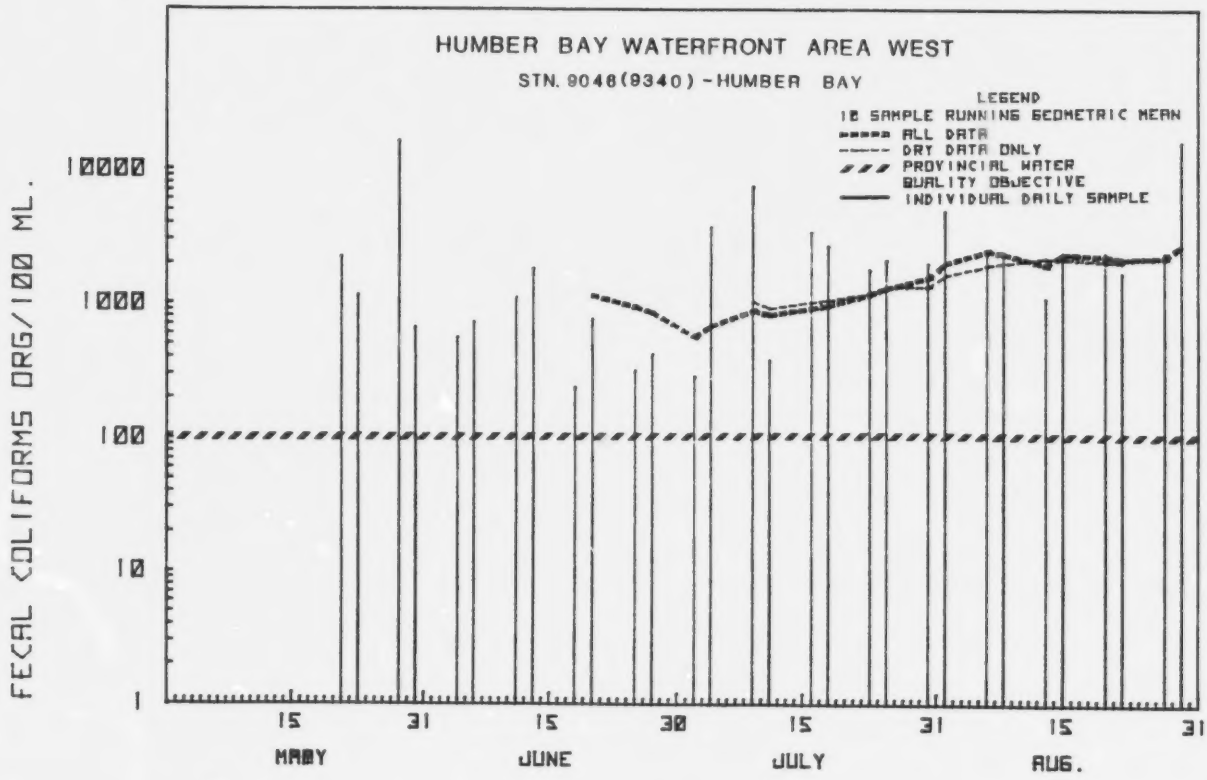
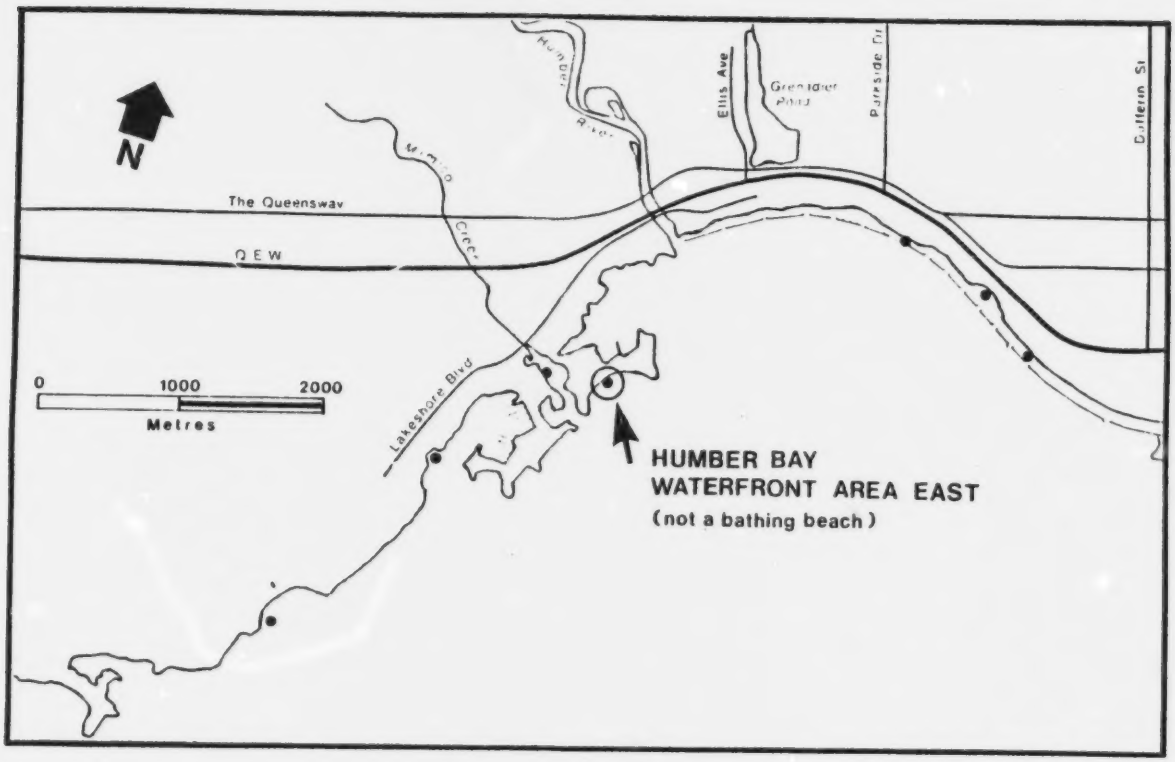


FIGURE 3.2.12: TEMPORAL TRENDS IN FECAL COLIFORM DENSITIES AND THE EFFECT OF THE WET WEATHER FLOW ON THE RUNNING GEOMETRIC MEAN, HUMBER BAY - 1985.



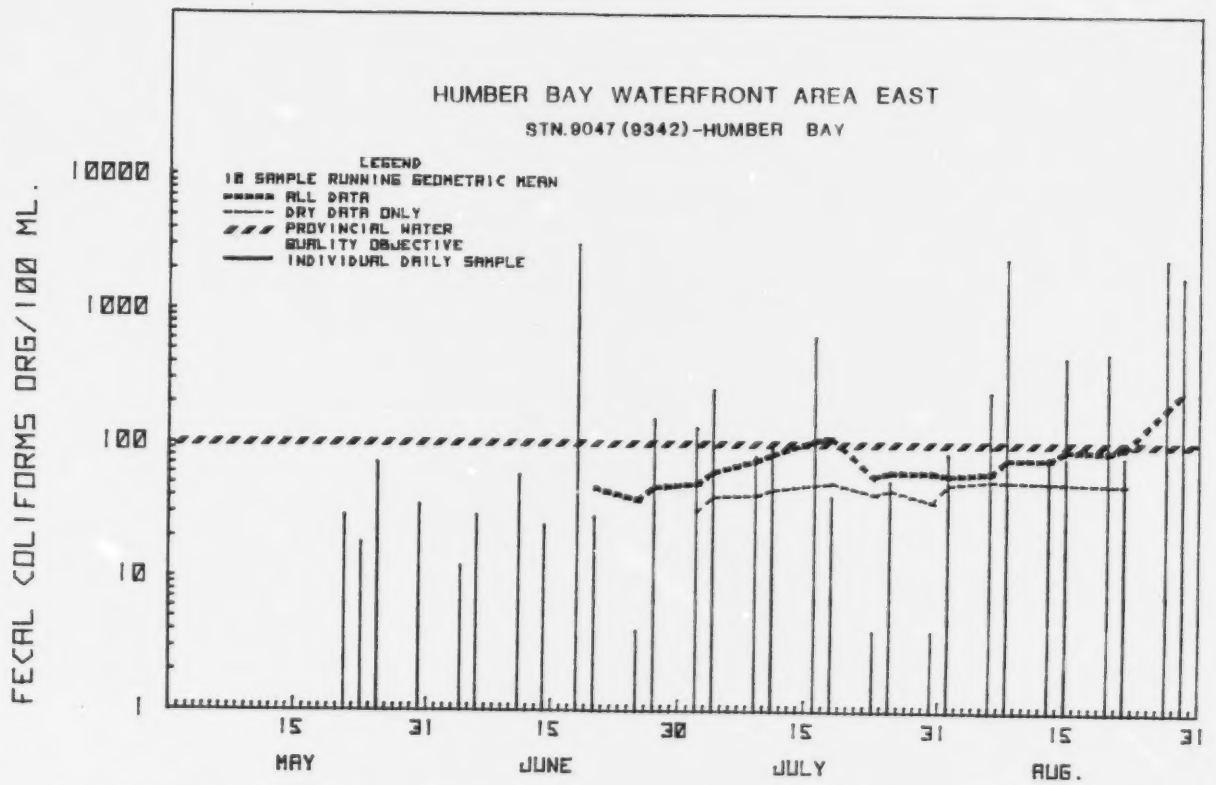
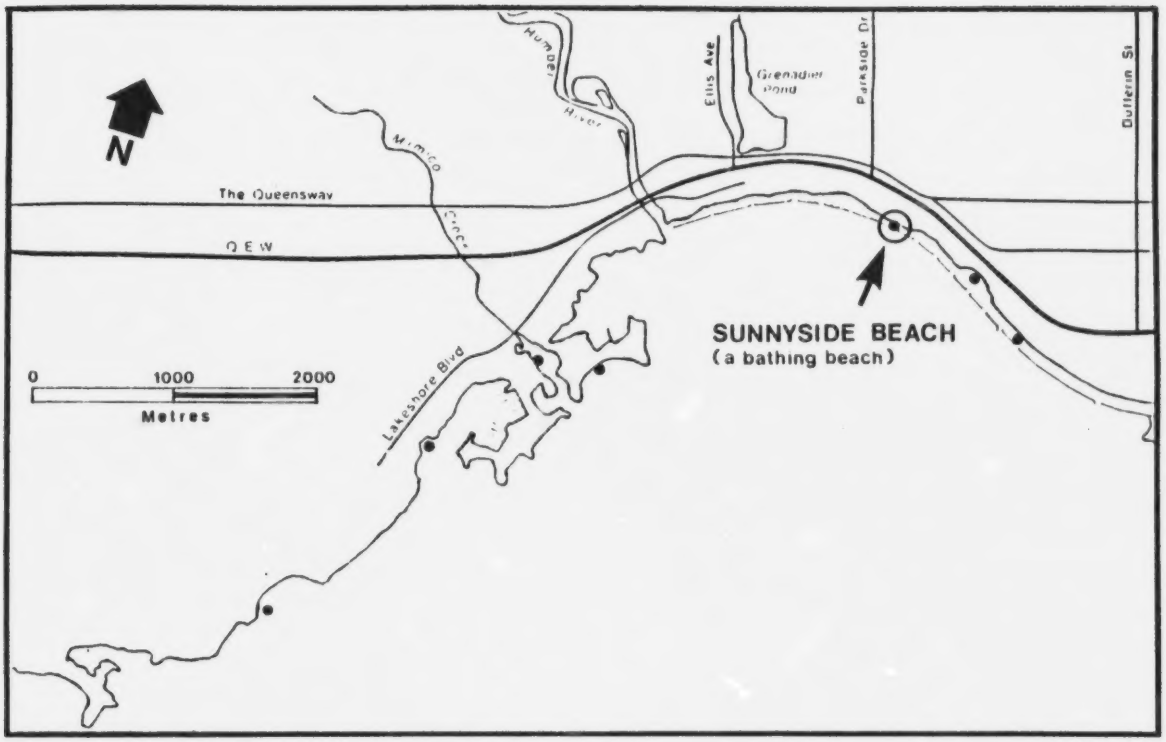


FIGURE 3.2.13: TEMPORAL TRENDS IN FECAL COLIFORM DENSITIES AND THE EFFECT OF THE WET WEATHER FLOW ON THE RUNNING GEOMETRIC MEAN, HUMBER BAY - 1985.



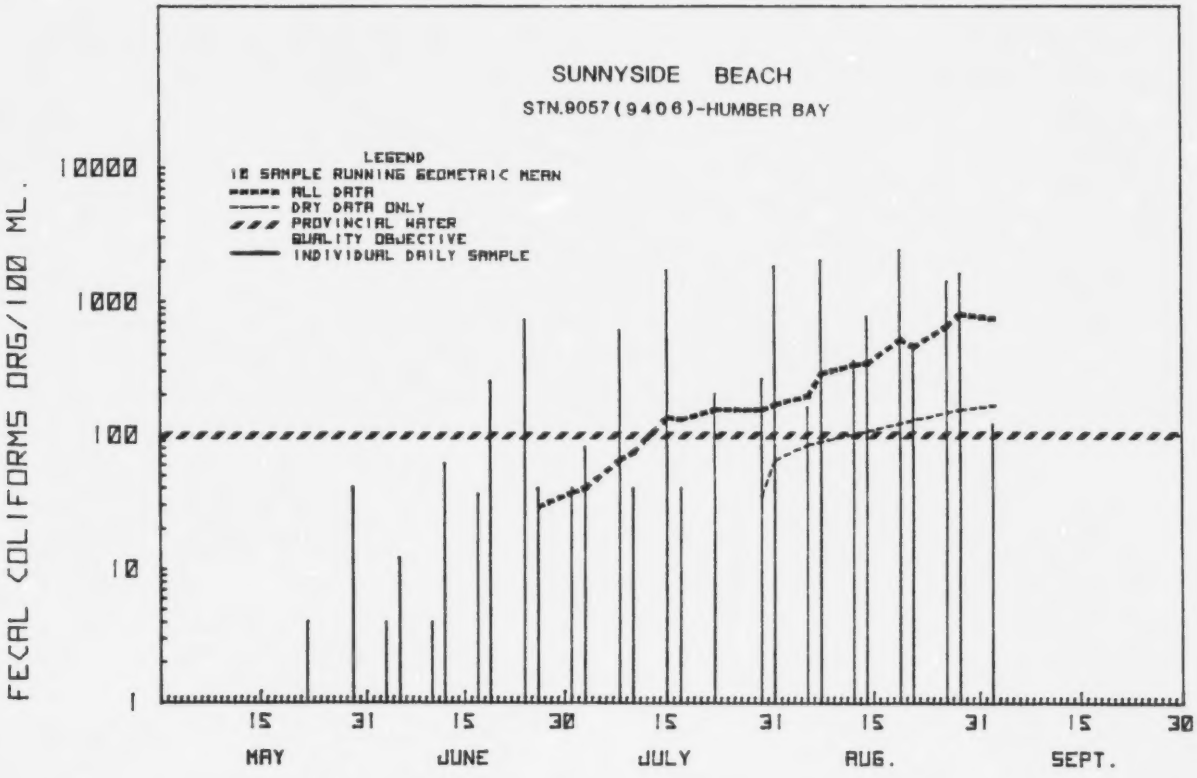
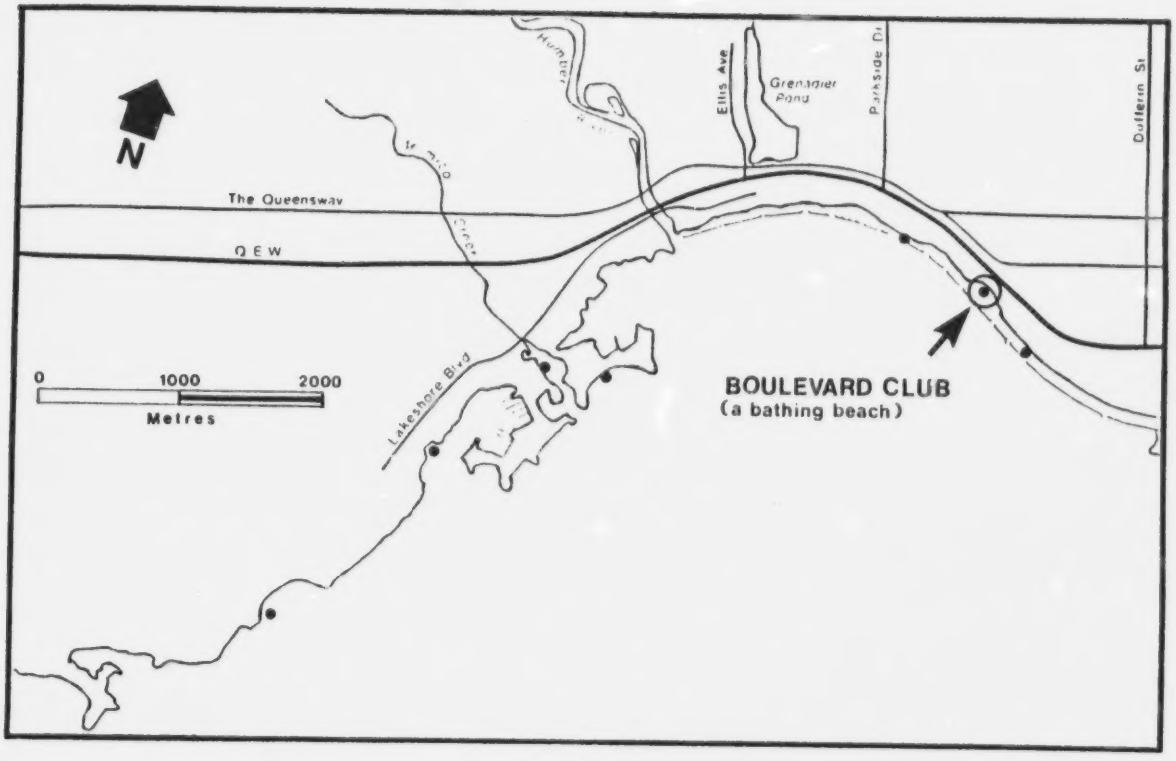


FIGURE 3.2.14: TEMPORAL TRENDS IN FECAL COLIFORM DENSITIES AND THE EFFECT OF THE WET WEATHER FLOW ON THE RUNNING GEOMETRIC MEAN, HUMBER BAY - 1985.



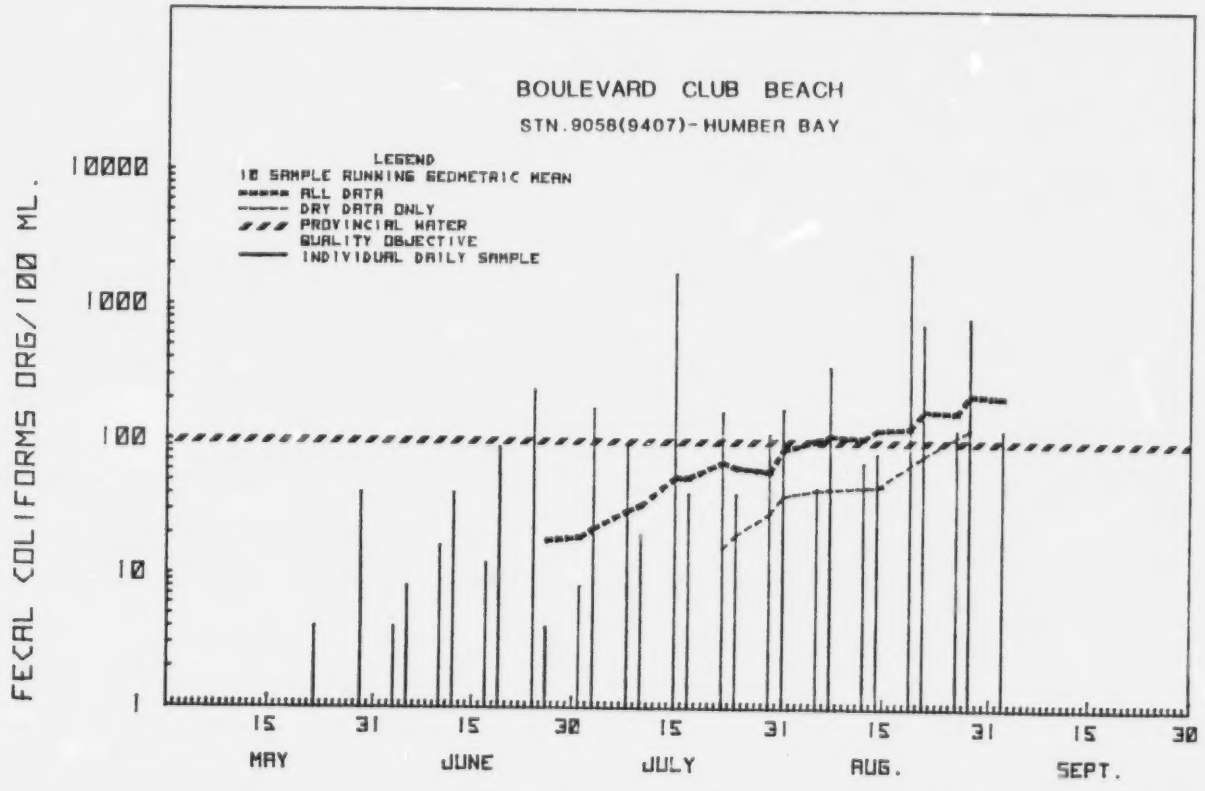
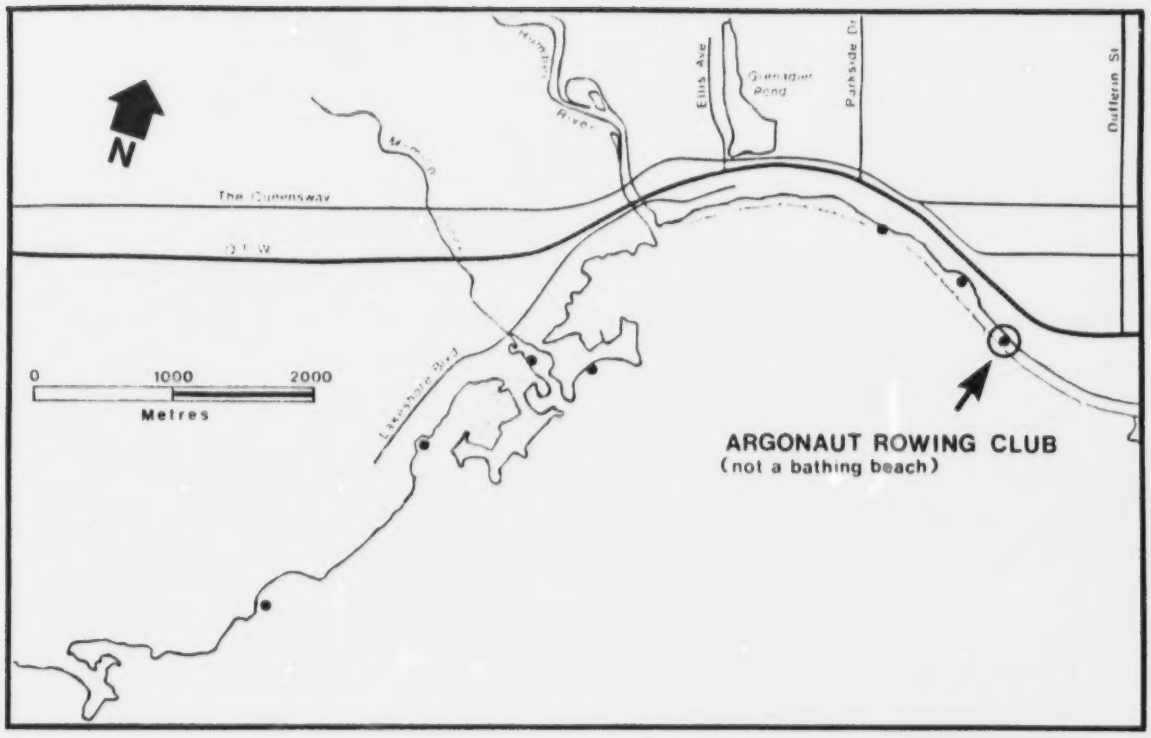


FIGURE 3.2.15: TEMPORAL TRENDS IN FECAL COLIFORM DENSITIES AND THE EFFECT OF THE WET WEATHER FLOW ON THE RUNNING GEOMETRIC MEAN, HUMBER BAY - 1985.



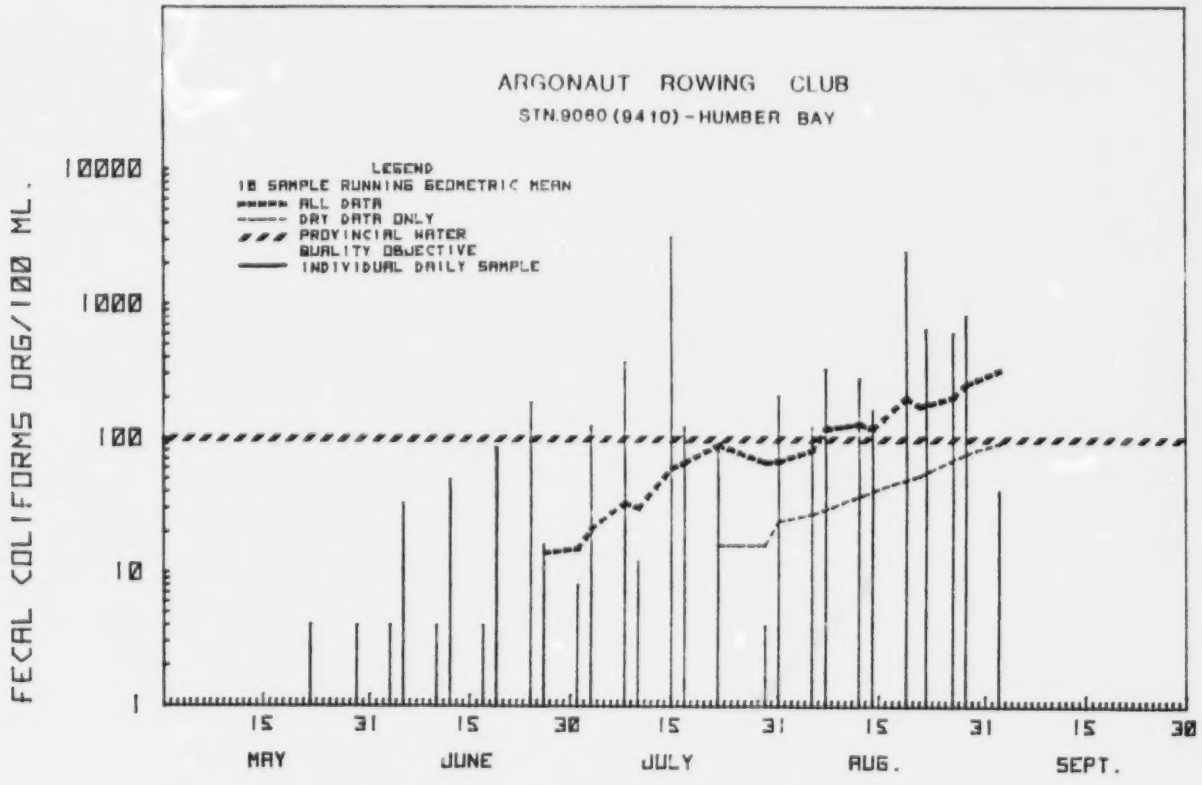


FIGURE 3.2.16: TEMPORAL TRENDS IN FECAL COLIFORM DENSITIES AND THE EFFECT OF THE WET WEATHER FLOW ON THE RUNNING GEOMETRIC MEAN, HUMBER BAY - 1985.

In contrast, distinct differences between dry-weather and all-weather running geometric means at the Western Beaches sites suggest that local storm related inputs from local combined overflow and storm sewers and overland inputs elevate bacterial levels above those prevailing during dry-weather conditions.

Extensive studies of the water exchange through the breakwater gaps by the City of Toronto Department of Works in 1986 have shown that the exchange through the gaps is a complex process varying in both time and depth. While the exchange processes are complex, the model predictions show that the day after runoff events the exchange is irrelevant because the fecal coliform densities outside and inside the breakwater are similar. However, the exchange through the breakwater is important in reducing the effects of runoff inside the breakwater in the second and third days after a storm.

A numerical model of Humber Bay has shown that the Humber STP outfall has no effect on the FC levels at the Western beaches (MacLarens 1986). Fecal coliform densities are so small by the time the Humber River plume reaches the Western Beach area that the plume does not affect the beach fecal coliform densities.

At all sampling sites, the running geometric mean of fecal coliforms consistantly increased toward the latter portion of the summer. Increased survival rates of bacteria related to warmer temperatures in combination with constant dry-weather loads from the Humber River and higher frequency of rainfall events may have been some of the factors contributing to this increase. Based on all-weather running geometric means of fecal coliforms for 1985, Amos Waites Park Beach became unsuitable for swimming by the end of June, Sunnyside Beach by mid July and Boulevard Club Beach by end of July. All these sites remained placarded for the remainder of the summer.

Spatial Distribution of Bacterial Levels Along the Western Beaches

The Western Beaches have been the subject of several investigations aimed at defining the causes of bacterial contamination and isolating the transport mechanisms (Gore & Storrie 1986, Kleinfeldt 1985). Data collected by Kleinfeldt for City Works Deptartment in 1985 were summarized by MOE and are presented in Figure 3.2.17 - 3.2.19. The data were divided into those collected during wet and during dry weather conditions and the two data sets were subjected to a clustering technique (El. Shaarawi and Kwiatkowski 1977) which groups statistically similar stations into zones. Geometric means for each zone as well as for individual stations are shown in the figures.

During dry weather, a distinct gradient of fecal coliforms was apparent behind the breakwall with highest concentrations near the Humber River mouth decreasing toward the east and lowest levels found near the Argonaut Rowing Club. Furthermore fecal coliform levels inside the breakwall were significantly higher than those outside the breakwall with the exception of an area near the Parkside Drive and Howard Park combined sewer overflows. This observation may indicate possible dry weather inputs and/or non-point sources such as bird droppings or sediment resuspension caused by boating or wave action contributions at these locations. During wet weather, fecal coliform levels were elevated both inside and outside the breakwall.

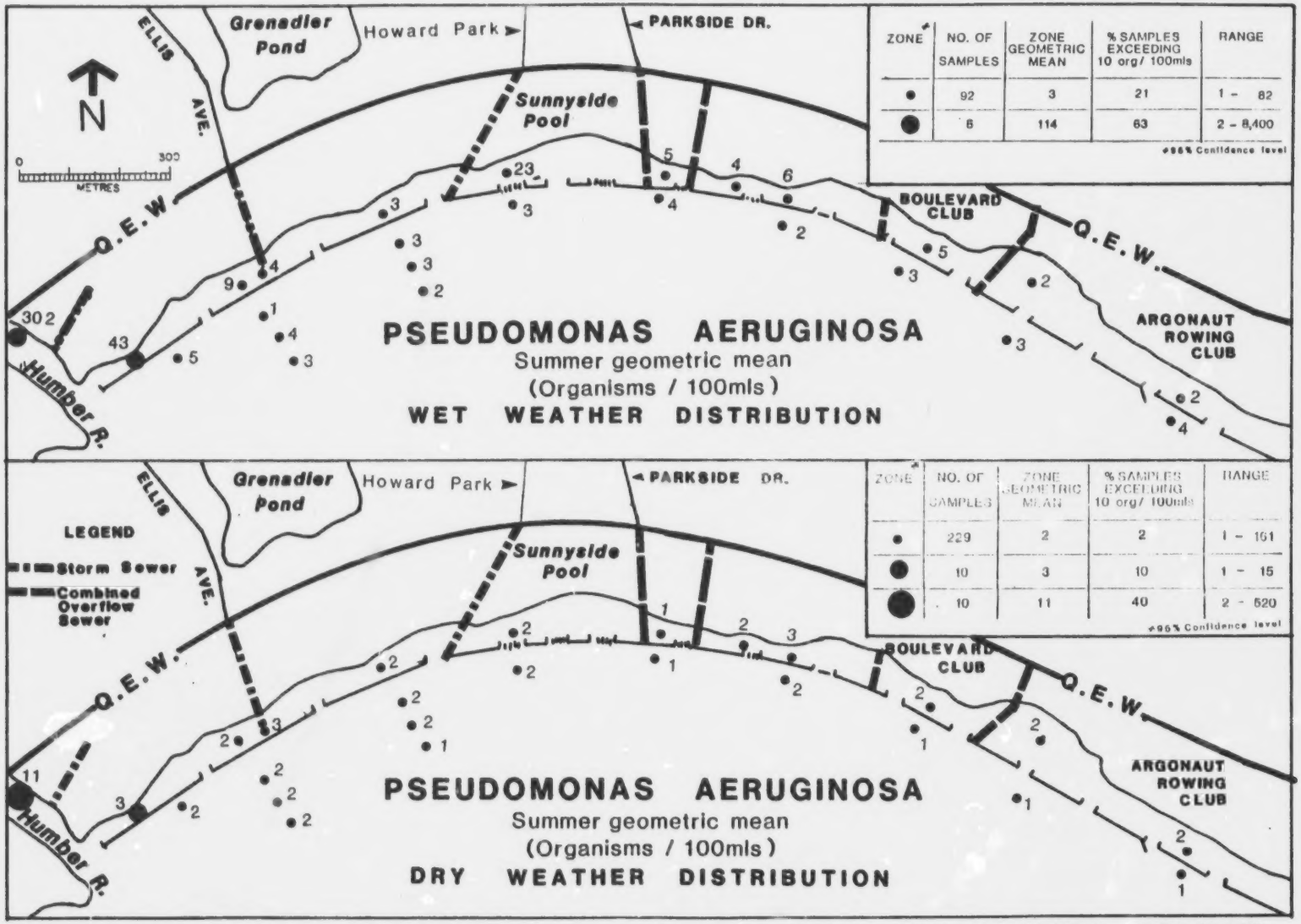

Grenadier Pond
Howard Park
PARKSIDE DR.
ELLIS AVE.
Sunnyside Pool
Q.E.W.
BOULEVARD CLUB
ARGONAUT ROWING CLUB
Humber R.
0 300
METRES
ZONE | NO. OF SAMPLES | ZONE GEOMETRIC MEAN | % SAMPLES EXCEEDING 10 org/ 100mls | RANGE
92 | 3 | 21 | 1 - 82
6 | 114 | 63 | 2 - 8,400
*95% Confidence level
PSEUDOMONAS AERUGINOSA
Summer geometric mean
(Organisms / 100mls)
WET WEATHER DISTRIBUTION
LEGEND
Storm Sewer
Combined Overflow Sewer
229 | 2 | 2 | 1 - 161
10 | 3 | 10 | 1 - 15
10 | 11 | 40 | 2 - 520
PSEUDOMONAS AERUGINOSA
Summer geometric mean
(Organisms / 100mls)
DRY WEATHER DISTRIBUTION

FIG 3.2.17 : SPATIAL DISTRIBUTION OF BACTERIA ALONG THE WESTERN BEACHES, SUMMER 1985 (based on City Works data)

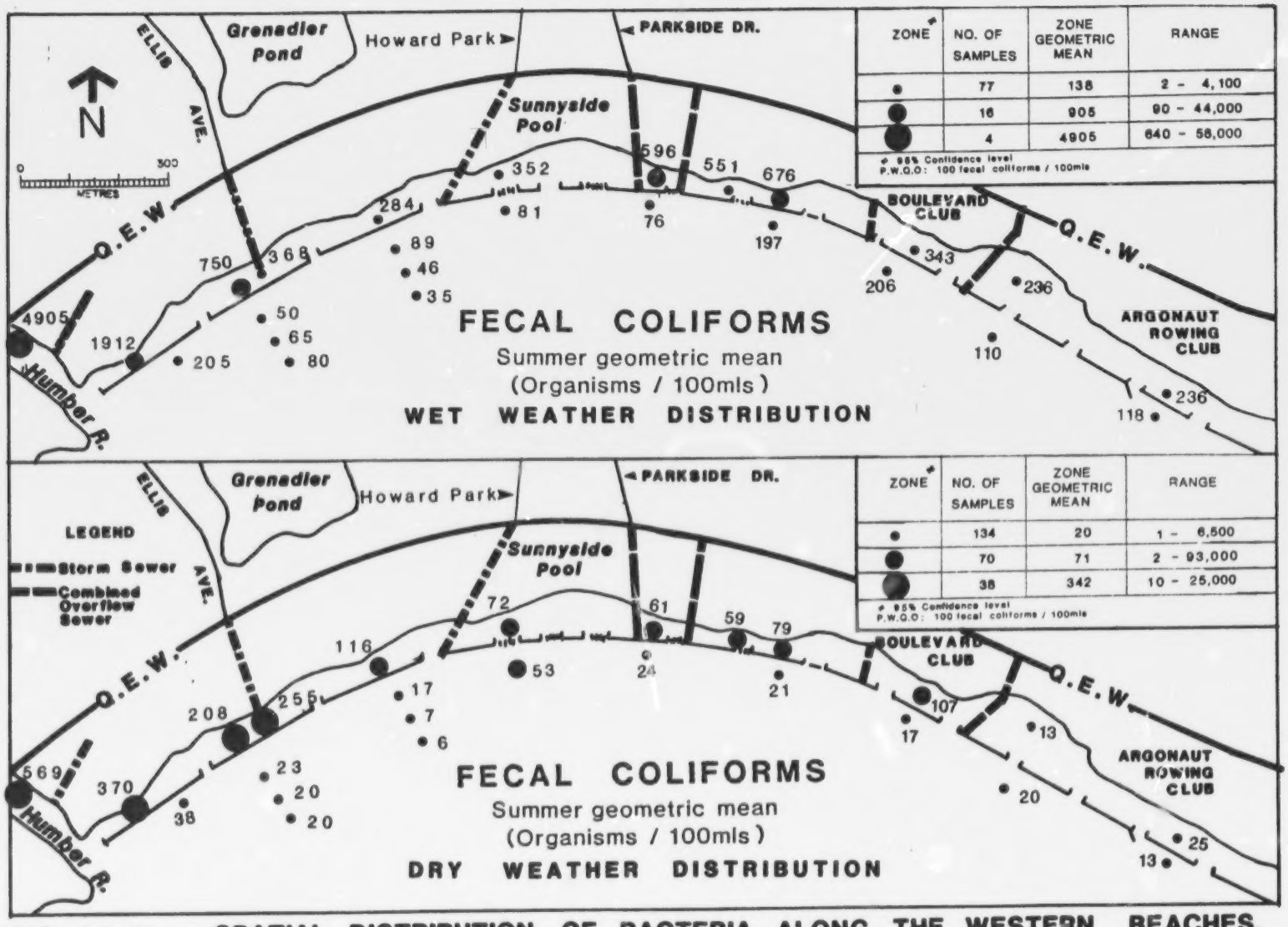


FIG 3.2.18 : SPATIAL DISTRIBUTION OF BACTERIA ALONG THE WESTERN BEACHES, SUMMER 1985 (based on City Works data)

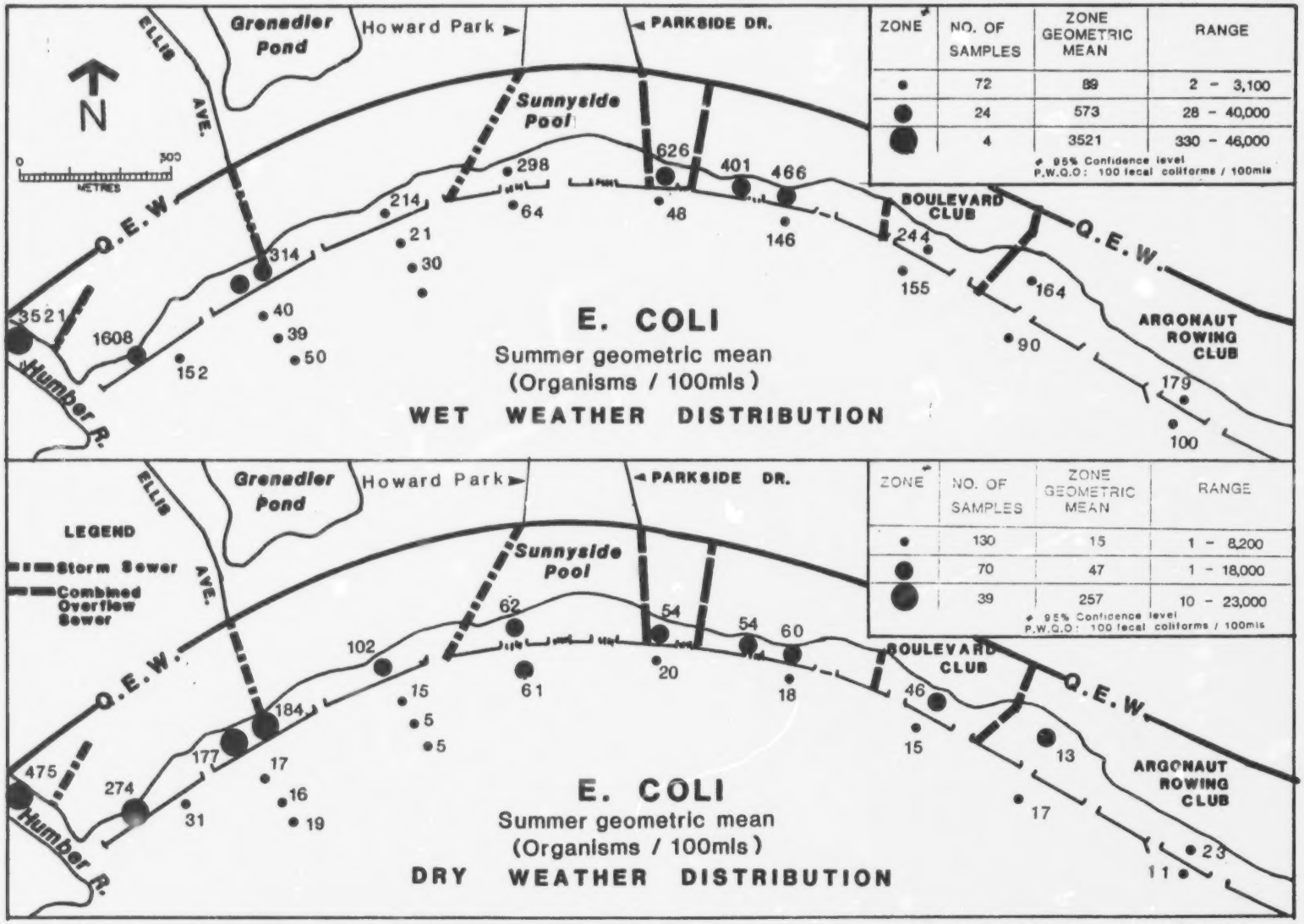


FIG 3.2.19: SPATIAL DISTRIBUTION OF BACTERIA ALONG THE WESTERN BEACHES, SUMMER 1985 (based on City Works data)

CONTAMINANTS

Lake stations located near the three major sources of inputs to Humber Bay (Humber River, Mimico Creek and Humber STP) were monitored in 1983 and 1985 for trace contaminants (metals, organochlorine pesticides, PCBs) in water (Figure 3.2.21). Results of this investigation are summarized in Tables A-1 and A-2 (Appendix).

Provincial water quality objectives (PWQO) were exceeded near some of these inputs for cadmium, copper, iron, lead, nickel, and zinc. The greatest frequency of PWQO violations for metals was found near the Humber STP followed by Mimico Creek and Humber River. Similarly, highest maximum concentrations of metals were also found near the STP outfall. These preliminary data suggest that copper is possibly the most significant metal of concern as it was frequently found in concentrations above those considered adequate to protect aquatic life.

A brief summary of the results is provided below.

Summary of heavy metal levels in water near point source inputs (1985)

Metal	PWQO ug/L	% of samples exceeding PWQO and (max. values) at		
		Mimico Creek mouth	STP outfall	Humber River mouth
arsenic	100	0 (1)	0 (1)	0 (1)
cadmium	0.2	25 (0.7)	58 (0.8)	16 (0.3)
chromium	100	0 (5)	0 (18)	0 (9)
copper	5	42 (7)	83 (20)	33 (7)
iron	300	16 (340)	91 (970)	25 (1400)
lead	25	0 (7)	8 (74)	0 (6)
nickel	25	0 (14)	25 (30)	0 (6)
zinc	30	16 (50)	33 (80)	0 (16)

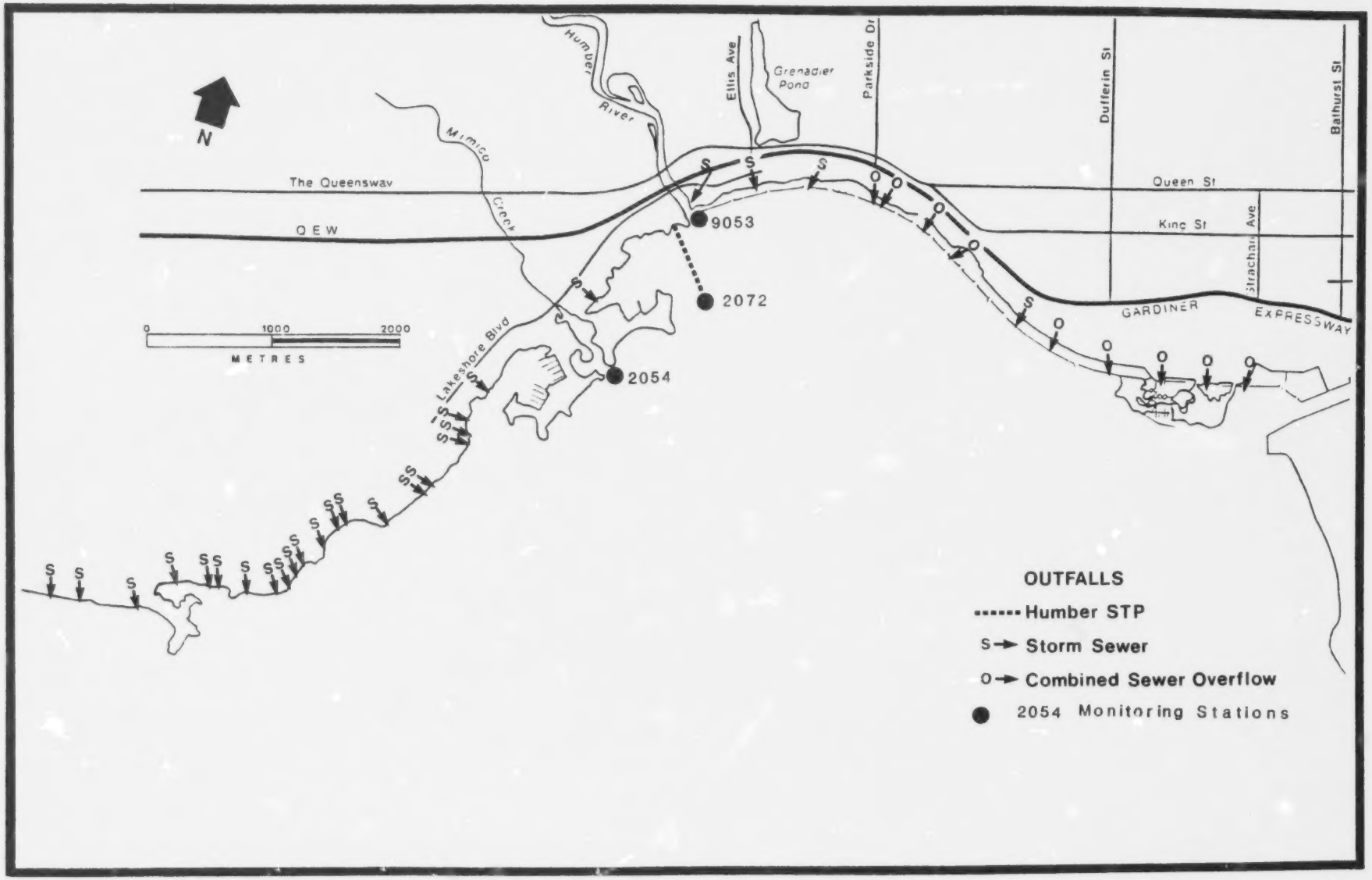


FIGURE 3.2.21 LOCATIONS OF CONTAMINANT MONITORING STATIONS

Several organochlorine compounds were detected near the input sources. These included trichlorobenzene, tetrachlorobenzene, α,β and γ BHC, pentachlorophenol and HCB (hexachlorobenzene). All of the above were found in trace amounts only and were never found to exceed the existing PWQO. PCBs and DDTs were not found in the waters of Humber Bay at present detection levels based on this limited sampling.

WATER SUPPLY

Monitoring for arsenic, nickel, zinc, copper, lead, chromium and barium at the R.L. Clark water treatment plant intake during the 1982-1985 period showed that these substances occurred at levels below Ontario Drinking Water Objectives even in the raw water. Arsenic was found at the detection limit of 0.001 mg; lead occurred at 0.003 to 0.004 mg/L and barium at about 0.002 mg/L. Nickel and zinc occurred in the range of 0.001 to 0.005 mg/L.

Levels of both copper and iron fluctuated from year to year. Based on average values the intake water contained 0.51 mg/L in 1982, 0.006 mg/L in 1983, 0.019 mg/L in 1984 and 0.013 mg/L in 1985 of copper. Similarly, iron occurred at 0.081 mg/L in 1982, was not analysed for in 1983, at 0.035 mg/L in 1984 and 0.057 mg/L in 1985. The Ontario Drinking Water Objective (ODWO) for iron of 0.3 mg/L is set on aesthetic considerations.

Since these averages are based on only 2 or 3 analyses however, a single high reading, perhaps as a result of past sampling procedures or in-line contamination, could skew the results. Cadmium occurred in the range 0.002 mg/L to <0.2 mg/L. The ODWO for cadmium is 0.005 mg/L.

In the case of organic substances, some pesticides were infrequently encountered (some cases only once over a four year period) at detection limit or at slightly above. These include pp-DDD, pp-DDT, pp-DDE, Mirex, dieldrin, aldrin, α and γ chlordane, endosulphan 1,2 and sulphate, heptachlor and heptachlor epoxide and atrazine. Alpha BHC however was encountered in most raw water samples in trace levels to a maximum of .009 ug/L; this breakdown product of lindane is one of the most pervasive contaminants in the Great Lakes.

Dichloromethane, 1,4-dichlorobenzene, carbon tetrachloride, 1,1,1-trichloroethane, tetrachloroethylene, phenanthrene, and 1,2, dichloroethane were found at trace levels, usually only on one occasion. There are insufficient data to perceive any definite trends in the occurrence of trace organic contaminants. However, once the province-wide Drinking Water Surveillance Program is established at these water treatment plants, any such trends will be identified.

Conventional water treatment processes are effective in the removal of many contaminants of concern such as heavy metals and organics adsorbed to particulate material. The treated drinking water produced by the R.L. Clark water treatment plant has never exceeded any health-related Ontario Drinking Water Objectives or any guidelines for drinking water set by other jurisdictions, such as the U.S. Environmental Protection Agency, the World Health Organization or Health and Welfare, Canada.

The values reported above were obtained from the data summaries supplied by Metropolitan Toronto's Department of Public Works, from their own drinking water monitoring program.

Although Ontario's Drinking Water Objectives apply only to treated drinking water, they were cited here so that the concentrations found in lake waters could have some basis for comparison.

3.3 SEDIMENT QUALITY

Three sediment surveys conducted in Humber Bay and discussed here have been extensively reported upon in a publication entitled "Historical Development and Quality of the Toronto Waterfront Sediments" (Persaud et al 1985). The information presented will detail the Bay's most recent sediment type and quality and will describe temporal trends.

In 1979, a comprehensive sediment survey of Humber Bay was carried out at 40 stations. The sediments behind the Humber Bay breakwall were sampled in 1983. The samples from all three surveys were analyzed for particle size, total phosphorus, loss on ignition, total Kjeldahl nitrogen, total organic carbon, cadmium, chromium, copper, mercury, lead, zinc, solvent extractables and PCBs.

The sediment results from the three sediment surveys were compared to the MOE Open Water Disposal Guidelines for Dredged Material. These guidelines are used to determine the degree of contamination and indicate whether sediments could be disposed of in the open water. Parameters in excess of the guidelines are termed contaminated (highly contaminated when two times in excess of the guideline). Parameters below the guidelines are termed clean or uncontaminated.

Based on 1979 results, the sediment type and sediment quality in Humber Bay could be delineated into three zones. A strip of coarse (sand), clean material was identified along the shoreline on the west side of the Toronto Islands continuing over to Sunnyside Beach. As well, pockets of coarse, clean, material were found to the west of the Bay. Fine (silts and clays), contaminated material was found in the inner portion of the Bay extending lakeward. The sediment sampled in this area was contaminated with organic material, nutrients, metals, solvent extractables and PCBs. The highly contaminated zone was the area extending from the Humber River around the Humber Sewage Treatment Plant outfall over to Mimico Creek. This fine material was highly contaminated with the above mentioned parameters. (Figure 3.3.1). Table 3.3.1 summarizes mean concentrations of several key parameters in the three zones.

In 1982, the sediment type and quality of the inner Bay was found to be similar to that of the 1979 survey. The only minor change was that PCB values in sediment were found to be slightly lower when compared to the 1979 survey.

In 1983, the sediment quality behind the Humber Bay breakwall appeared patchy varying between clean and contaminated material. The sediment near the Humber River and close to the Boulevard Club was coarse, clean material. The sediment in the areas in between was fine, contaminated material. This material had elevated levels of phosphorus, cadmium, copper, chromium, lead, zinc, solvent extractables and PCBs.

Though a 1983 in-place pollutants program, the MOE has determined that biota in the sediments of Humber Bay concentrate a variety of pollutants in their tissues. The chemicals bioaccumulated by the biota and summarized in Figure 3.3.2 include the metals, mercury, zinc, copper and organic compounds such as PCBs, DDD, DDE, HCB, α BHC, chlordane, heptachlor and aldrin.

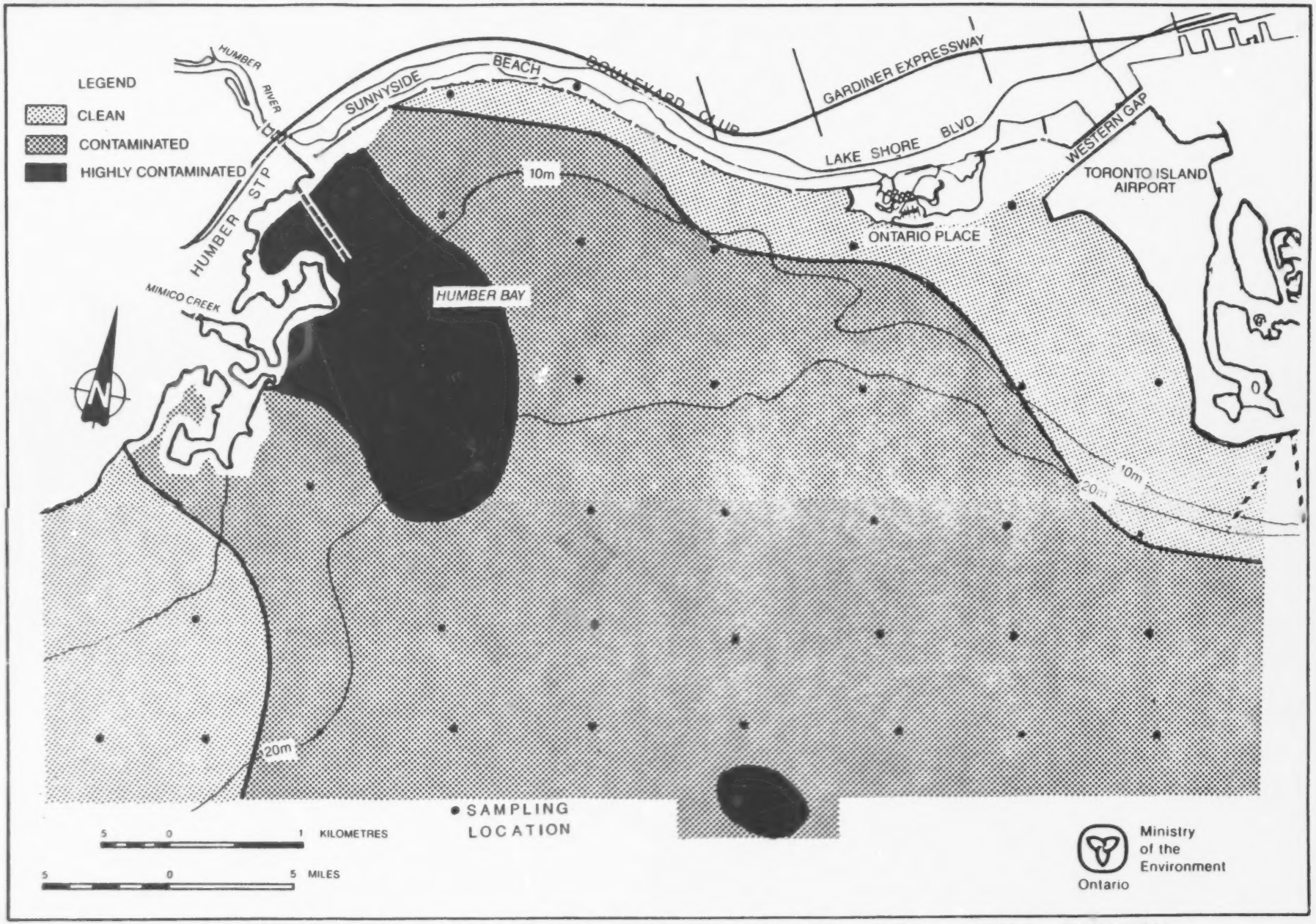


FIGURE 3.3.1 SEDIMENT QUALITY ZONES WITHIN HUMBER BAY, 1979 SURVEY.

TABLE 3.3.1: Mean Concentrations for Contaminants in the Three Zones Identified in Humber Bay from the 1979 Sediment Data

ZONE	LOI %	TP mg/g	TKN mg/g	TOC mg/g	TOTAL PCB ng/g	Hg ug/g	Cd ug/g	Cr ug/g	Cu ug/g	Pb ug/g	Zn ug/g	Solvent Extractables ug/g
STP Zone												
Mean	7.6*	3.8*	4.1*	28.1*	468*	0.65*	9.98*	308.2*	133.8*	246.0*	601*	8630*
Range	(7.1-8.2)	(1.3-7.4)	(2.2-6.7)	(20.0-31.0)	(200-700)	(0.32-1.20)	(2.2-22.00)	(86-665)	(66.0-265.0)	(110.0-520.0)	(210-1225)	(3550-16440)
Shoreline Zone												
Mean	1.3	0.7	0.4	1.7	56*	0.22	0.48	12.6	10.4	23.8	38	576
Range	(1-3)	(0.3-1.3)	(0.1-1.1)	(0.4-3.6)	(20-150)	(0.01-0.84)	(0.30-1.10)	(3-80)	(3.0-40.0)	(6.56)	(17-170)	(150-1350)
Mid Bay Zone												
Mean	4.1	1.2*	1.6	14.6*	292.8*	0.27	1.59*	68.20*	41.7*	74.04*	135*	1784*
Range	(1.4-5.7)	(0.6-2.4)	(0.3-2.5)	(<0.1-22.3)	(30-1330)	(0.02-0.54)	(.04-4.30)	(16.0-130.0)	(8.0-80.0)	(14-130)	(14-280)	(377-3820)
MOE Guidelines	6.0	1.0	2.0	10.0**	50	0.30	1.00	25.0	25.0	50.0	100	1500

* Equals or exceeds MOE Guidelines

** Interim Guideline

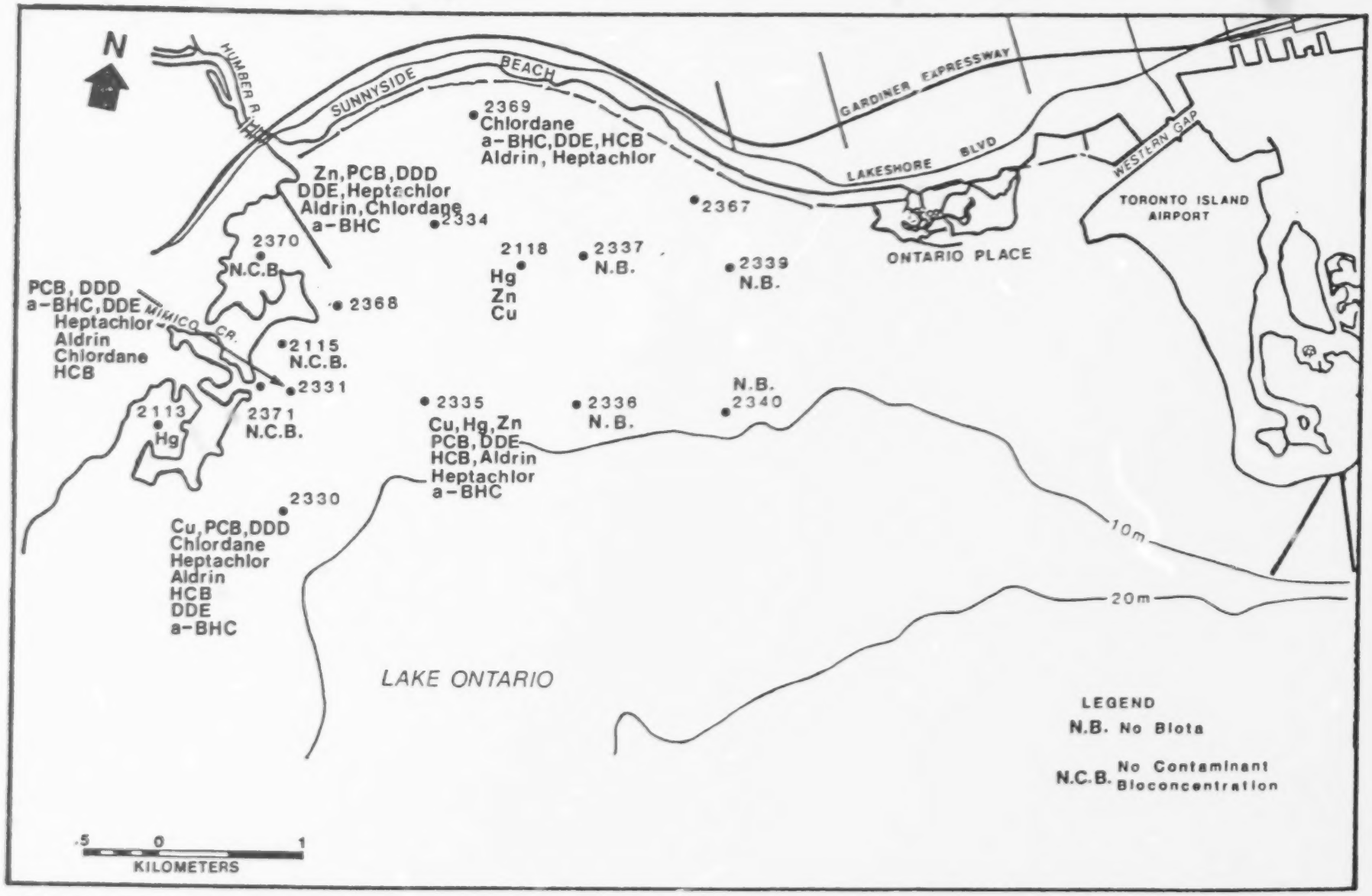


FIGURE 3.3.2: HUMBER BAY- STATION LOCATIONS AND PARAMETERS SHOWING BIOCONCENTRATION FACTOR ≥ 1

3.4 BIOTA

BENTHIC INVERTEBRATE COMMUNITY

The most recent benthic invertebrate study of Humber Bay (Barton, 1980) has concluded that the majority of the fauna is composed of tubificids. More than 70% of the invertebrates collected in 1979 at 16 stations were Tubificidae worms. The sites supporting the tubificids roughly corresponded to the ones with the highest invertebrate densities (Figure 3.4.1). Most of these worms were Limnodrilus spp and Tubifex tubifex, both known to be species tolerant to organic pollution. Midge larvae of the family Chironomidae represented only a small portion of the organisms.

Largest total standing stocks of invertebrates (>150,000 organisms m^{-2}) were found near of the Humber River and Mimico Creek outlets. In most other areas of Humber Bay, standing stocks ranged from 50,000 - 100,000 organisms m^{-2}. The lowest invertebrate numbers were found near the Humber STP outfall likely reflecting the toxic effect of residual chlorinated compounds in the effluent. An earlier study near the outfall (Cockburn, 1976) found an area of about 120,000 m^3 (Figure 3.4.1) virtually devoid of benthic invertebrates. Leaf litter, found in the samples from this area was not decomposing, indicating that micro-organisms responsible for the breakdown of this matter were also absent.

Overall, the results of the 1979 invertebrate study indicated that much of Humber Bay is oligotrophic to mesotrophic with an enriched (eutrophic) zone in the area affected by the plumes from the Humber River and Mimico Creek. The 1976 study concluded that the lakefilling operation at the Humber Bay Waterfront Area site had a detrimental impact on the local benthic community. It suggested that the design of the embayment at the lakefill site contributed to entrapment of sediments resulting in a definite change in the invertebrate species composition. Furthermore, the proximity of the eastern end of the lakefill to the Humber STP outfall appeared to interfere with effluent dispersion and created a localized toxic zone.

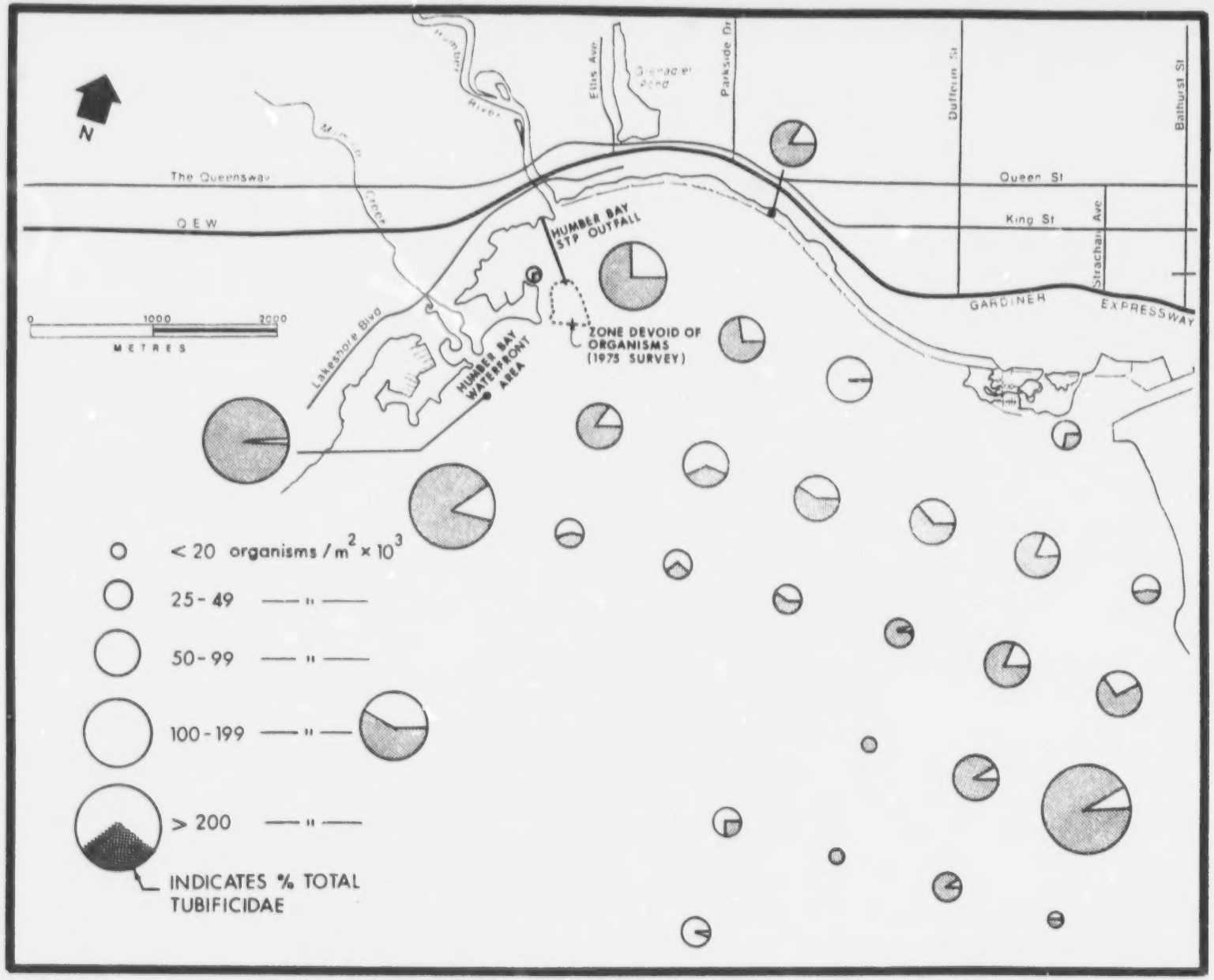


FIGURE 3.4.1 MEAN ESTIMATES OF TOTAL STANDING STOCK OF INVERTEBRATES FROM HUMBER BAY, BASED ON A 1979 STUDY.

CONTAMINANT LEVELS IN SPOTTAIL SHINERS

Young-of-the-year spottail shiners (Notropis hudsonius) have proven to be sensitive biomonitors for organochlorine compounds and metals. Accumulated residues of these substances reflect the most recent water quality conditions and bioavailability of contaminants for a given locality. Due to their restricted nearshore habitat, young-of-the-year spottail shiners have useful applications in compliance monitoring and the detection of recently introduced persistent contaminants from land-based sources. An early warning system, spottail shiner surveillance can identify emerging problems well before open lake responses become apparent. A recently published study (Suns et al 1985) reports on recent temporal trends of mercury and organochlorine residues in Great Lakes spottail shiners.

PCB, ∑DDT, ∑BHC and ∑chlordane residues in spottail shiners have declined significantly ($p<0.05$) in the Humber River and Mimico Creek collections. (Table 3.4.1).

While the residue reductions have been considerable, particularly in the late 1970's, recent (1983) PCB residue levels in juvenile spottail shiners still exceeded the IJC Aquatic Life Guideline (100 ppb) at the Humber and Mimico Creek sites. The DDT residues, on the other hand, are well below the IJC Aquatic Life Guidelines of 100 ppb.

Chlorobenzene and chlorophenol residues were largely absent in the spottail shiners except for elevated pentachlorophenol levels in the 1981 collection from Mimico Creek. These abnormally high pentachlorophenol residues were likely associated with a spill of unknown origin.

Mercury in juvenile spottail shiners was not detected in fish collected at the Humber River and Mimico Creek sites.

CONTAMINANT LEVELS IN SPORT FISH

Smelt, White Sucker and Rainbow Trout in the Humber Bay area were tested in 1985 for mercury, PCB, mirex, organochlorine pesticides and the dioxin, 2,3,7,8-TCDD and were found to be suitable for unlimited consumption at all sizes tested (Table 3.4.2). Lake Trout up to 45 cm

TABLE 3.4.1: Contaminant Levels in Young-of-the-Year Spottail Shiners (all values ng/g, i.e. ppb)

	YEAR	NO. OF SAMPLES	PCB	∑DDT	MIREX	∑BHC	∑CHLORDANE	PENTACHLORO-PHENOL	MERCURY
Mimico Creek	1981	5	1051 ± 105	135 ± 19	ND	19 ± 2	47 ± 3	1467 ± 153	NA
	1982	6	572 ± 45	52 ± 7	TR	5 ± 2	17 ± 3	213 ± 12	30 ± 0
	1983	7	542 ± 80	41 ± 4	ND	6 ± 2	25 ± 3	ND	NA
Humber River	1977	8	2218 ± 263	268 ± 32	5 ± 2	41 ± 8	58 ± 16	NA	44 ± 5
	1978	8	2938 ± 391	406 ± 99	15 ± 4	3 ± 4	ND	NA	36 ± 7
	1979	8	1223 ± 347	76 ± 12	ND	4 ± 1	47 ± 9	ND	30 ± 19
	1980	6	621 ± 66	41 ± 4	ND	15 ± 5	36 ± 6	NA	22 ± 4
	1981	6	954 ± 45	86 ± 41	ND	9 ± 3	26 ± 9	NA	NA
	1982	6	353 ± 70	28 ± 20	ND	3 ± 0	22 ± 1	ND	NA
	1983	7	537 ± 122	48 ± 7	ND	5 ± 1	21 ± 2	NA	NA
IJC Aquatic Life Guidelines			100	1000	Absent	NA	NA	NA	500

Table 3.4.2. - Contaminant Levels in Sport Fish Collected in Humber Bay

YEAR	SPECIES	NO	LENGTH (CM)			WEIGHT (GM)			Hg (PPM)			PCB (PPB)			MIREX (PPB)		
			MEAN	MIN	MAX	MEAN	MIN	MAX	MEAN	MIN	MAX	MEAN	MIN	MAX	MEAN	MIN	MAX
1981	W. Sucker	97	37.7	20.8	49.5	709	115	1625	.15	.03	.53	696	80	3451	7	ND	151
	L. Trout	39	44.2	23.0	66.2	1014	100	3600	.20	.04	.52	1874	170	10000	99	ND	370
	Smelt	9	17.1	14.9	20.2	32	20	48	.09	.05	.18	740	300	1110	43	19	78
	W. Perch	1	20.0	-	0	130	-	-	.20	-	-	425	-	-	13	-	-
	Alewife	2	13.0	11.3	14.6	15	10	21	.09	.04	.14	1086	852	1320	60	30	90
	Cisco	3	32.5	31.7	33.0	327	300	350	.04	.02	.06	498	360	636	13	10	16
	Y. Perch	1	19.0	-	-	90	-	-	.15	-	-	170	-	-	8	-	-
	Whitefish	1	45.0	-	-	900	-	-	.06	-	-	735	-	-	13	-	-
	B. Trout	1	49.0	-	-	1825	-	-	.13	-	-	1153	-	-	34	-	-
	R. Trout	16	36.8	22.5	51.5	809	115	2000	.09	.01	.22	748	130	1917	22	ND	60
	L.N. Sucker	1	29.0	-	-	300	-	-	.05	-	-	87	-	-	ND	ND	ND
1976	Smelt	5	15.0	13.0	20.7	107	65	165	.09	.06	.13	-	-	-	-	-	-
	W. Sucker	11	35.7	31.2	40.3	595	350	900	.13	.01	.20	-	-	-	-	-	-
1975	Perch	1	19.0	-	-	195	-	-	.22	-	-	35	-	-	-	-	-
	Sucker	12	59.0	29.0	42.0	460	220	815	.16	.06	.29	1693	500	3150	-	-	-
	B. Bullhead	2	27.5	26.5	28.5	298	255	340	.36	.26	.41	-	-	-	-	-	-
	W. Bass	1	16.0	-	-	65	-	-	.05	-	-	-	-	-	-	-	-
	Smelt	1	19.5	-	-	45	-	-	.14	-	-	-	-	-	-	-	-
	Pumpkinsd	1	16.0	-	-	90	-	-	.52	-	-	-	-	-	-	-	-
	W. Sucker	5	41.6	40.0	44.0	766	690	890	.16	.10	.24	1735	540	3500	-	-	-
	Consumption Guidelines									.5			2000			100	

(18 inches) were tested for the same substances and were also suitable for unlimited consumption. Larger Lake Trout exceeded the acceptable levels of PCB and Mirex in their flesh and were suitable only for limited consumption (1986 Guide to Eating Ontario Sport Fish).

Contamination of sport fish caught in Humber Bay may not be necessarily related only to local inputs. For instance, Mirex found in Lake Trout probably orginated predominantly from the Niagara River. The origin of PCB contamination in sport fish collected in the Bay is likely a combination of local as well as lake-wide inputs.

Restoration of the fishery must therefore proceed on basis of lake-wide abatement strategy and must address all major inputs and not only those associated with Toronto Waterfront.

4.0 IDENTIFICATION AND DELINEATION OF SPECIFIC CONCERNS

The surface waters of Humber Bay and its immediate vicinity are put to many uses, each requiring a minimum acceptable water or sediment quality. To date, the drinking water from the R.L. Clark water treatment plant has not exceeded any Ontario Drinking Water Objectives or any guidelines for drinking water set by other jurisdictions.

4.1 BODY CONTACT RECREATION

Beaches west of the Humber River (including Amos Waites) have been permanently posted for many years as a result of historically high bacterial levels.

The Western Beaches have been intermittently posted by the City of Toronto Department of Public Health since the summer of 1983 when elevated fecal coliform levels have been found to exceed the current MOE guidelines for body contact recreation of 100 organisms/100 mls.

Since the Western Beaches respond to storm related inputs, they are now posted with signs similar to those used presently at the Eastern beaches which read "Warning, for 48 hours after a rainfall, this beach may be polluted, swimming during this period may be hazardous to health".

4.2 NON-BODY CONTACT RECREATION

The Humber Bay area is used extensively by pleasure boats for sailing, cruising and mooring. Concern over pleasure boating relates to the adverse effect of algae and turbidity on the water's aesthetic quality and fouling of boat hulls and propellers by algae growths. Filamentous algal growths in the forms of Cladophora are also of concern to users of the Humber Bay beaches and shoreline areas. Accumulations of detached Cladophora, especially along the Etobicoke shore, have, in the past interfered with beach and lakefront use. These accumulations will persist as long as nutrient levels in the water permit extensive growth of the algae along the rocky subtrates which dominate the lake shoreline and in the offshore regions where shale outcroppings are common.

The risks of exposing windsurfers to sewage polluted waters may need closer investigation in the future in view of the frequent use of the Humber Bay Waterfront Area by windsurfers and its close proximity to known sources of fecal coliform inputs such as the Humber River, Humber STP and nearby storm and combined sewer overflows. Although at present no bacteriological guidelines for secondary body contact recreation such as windsurfing are available, recent literature reports an increased risk for infectious manifestations in windsurfers exposed to sewage-polluted waters (Dewailling et at 1986).

4.3 IN-PLACE POLLUTANTS

Of future concern may be the need to dredge certain parts of the Humber Bay Waterfront Area, especially its eastern embayment which is slowly becoming filled in by suspended sediment from the Humber River. Since the sediment in this embayment is contaminated at levels above MOE dredging guidelines, future dredging and dredge spoil disposal will have to be conducted in an environmentally acceptable manner.

The potential of contaminant release from sediments and subsequent uptake by biota is of concern. Preliminary studies in the Humber Bay area have suggested significant bio-magnification of contaminants by biota associated with sediments. This issue is further discussed in Section 3.3. Further studies are needed to assess the fate of contaminants in the aquatic food chain.

4.4 SPORT FISH

A potential concern with respect to sport fishing relates to chemical contamination of sport fish leading to restrictions on consumption. In Humber Bay, lake trout larger than 45 cms have been found to exceed acceptable levels of PCB and Mirex in their flesh, and are suitable only for limited consumption.

Contamination of sport fish caught in Humber Bay may not be necessarily related to local inputs only. Mirex found in lake trout is probably from the Niagara River since no local sources are known. Since many larger salmonids accumulate high body burdens of contaminants from the consumption of open lake smelt and alewife, it is questionable if remedial actions in Humber Bay would be sufficient to result in a contaminant-free fishery.

Restoration of the fishery must therefore proceed on basis of a lake-wide abatement strategy. The potential economic gain associated with a restored fishery is considerable. The social and economic impact evaluation of remedial action in Toronto will be one of the issues addressed by the Toronto Remedial Action Plan.

4.5 AQUATIC ENVIRONMENT

Although PCB levels in spottail shiners have declined in recent years, they still exceed the IJC Aquatic Life Guidelines of 100 ppb. Furthermore, the benthic invertebrate community is disrupted in the vicinity of major inputs. An area of 120,000 m^2 at Humber STP outfall was found in 1975 to be devoid of any benthic organisms. Construction of the Humber Bay Waterfront Area was found to have a detrimental impact on the local benthic community. In areas affected by nutrient-rich plumes from Humber River and Mimico Creek, a benthic community indicative of highly enriched conditions has developed.

The possibility of adverse impacts of contaminants from sediments and water on local aquatic organisms is presently under investigation. Preliminary results indicate that biota associated with Humber Bay sediments bioaccumulates the metals mercury, zinc, copper and a variety of organic contaminants including PCBs DDD, DDE, HCB, α BHC, chlordane, heptachlor and aldrin.

4.6 MUNICIPAL WASTEWATER ASSIMILATION

Several outfalls discharging to Humber Bay may be situated too close to shore for efficient effluent dispersion.

The end of the existing Humber STP outfall is only 250 meters away from the tip of the Humber Bay Waterfront Area lakefill. Its proximity to shore appears to affect the dispersion of its effluent. Both sediment and benthic invertebrate studies have shown an adverse effect of the Humber STP effluent on the immediate zone of impact. Metro Works Department is presently evaluating options for extending the Humber STP outfall further offshore in order to achieve better dispersion of effluent.

The proximity of combined sewer overflows to the Western beaches may be an important factor in degraded bacterial environment in the area. The semi-permeable breakwall does not appear effective in preventing local combined sewer discharges from intruding back towards the beach areas.

5.0 DESCRIPTION OF POTENTIAL SOURCES

The study area considered for pollutant source input analysis to Humber Bay, extended from Kipling Avenue in the west to the Western Gap in the east. Inputs into Humber Bay have been identified as the Humber River, the Humber Sewage Treatment Plant (STP), direct combined and storm sewer discharges to the Western Beaches (CSO), Mimico Creek, direct storm sewer discharges along the Etobicoke waterfront and Western Beaches and direct atmospheric deposition to Humber Bay.

5.1 LOADING SUMMARY

Concentration, volume and load estimates for phosphorus, suspended solids, metals and fecal coliforms, are presented in tables 5.1.1, 5.1.2 and 5.1.3. Estimates are preliminary and are based on simplified computations, due to limited data sets. Qualitative load assessments for major and minor pollutant sources, are provided in table 5.1.4.

The Humber STP and the Humber River are the primary source of metal and phosphorus inputs to Humber Bay. The Humber River is the predominant source of suspended solids.

TABLE 5.1.1 - AVERAGE ANNUAL POLLUTANT CONCENTRATIONS FOR INPUTS TO HUMBER BAY (1984)

	CONCENTRATIONS					
	STP[1]	CSO[2]	Mimico Creek[3]		Humber River[4]	
PARAMETERS	Average Annual Concentration	Average Annual Concentration	Average Dry Weather Concentration	Average Wet Weather Concentration	Average Dry Weather Concentration	Average Wet Weather Concentration
Total Phosphorus (TP), mg/L	1.43	1.96	0.022	0.378	0.021	0.351
Suspended Solids (SS), mg/L	26.2	131	26.75	92.55	6	200
Cadmium (Cd), ug/L	3.12	6.00	0.2	0.7	0.1	0.75
Copper (Cu), mg/L	0.023	.119	0.014	0.022	0.008	0.032
Lead (Pb), mg/L	0.013	0.182	0.006	0.031	0.003	0.027
Nickel (Ni), mg/L	0.175	N/A	0.002	0.013	0.003	0.008
Zinc (Zn), mg/L	0.130	0.300	0.028	0.085	0.006	0.045
Mercury (Hg), ug/L	0.26	N/A	0.04	0.033	0.03	0.039
Chromium (Cr), ug/L	15.2	N/A	6	23	4	9.5
Fecal Coliform (FC), geo. mean/100 mL						
disinfection: on	1 700					
off	30 000					
average annual		77 300				
dry weather			403[5]		839	
wet weather			417-5,672[5]		905-12,760[5]	

1 - Metropolitan Toronto, Trace Organic Analyses of Water Pollution Control Plant Effluents, Report 1 (1983), Report 2 (1984).
2 - SS - Dorsch Consult Limited, Study on Operational Behaviour of Principal City Interceptor Sewers, Volume 1 (1978).
FC - City of Toronto QQS Analysis (1987)
Other Parameters - TAWMS, Technical Report #7, Humber Sewershed Combined Sewer Overflow Study (1985).
3 - TAWMS, Technical Report #4, Humber River and Toronto Area Water Quality (1984).
4 - FC (Dry Weather) - TAWMS, Technical Report #13, Humber River Bacteria Sources and Pathways Study (1986).
FC (Wet Weather) - TAWMS, Technical Report #6, Humber River Bacteriological Study (1985).
- TAWMS, Technical Report #4, Humber River and Toronto Area Water Quality (1984).
Other Parameters - TAWMS, Technical Report #4, Humber River and Toronto Area Water Quality (1984).
5 - Values represent an initial screening based on limited data sets, and excluding winter and spring data. Wet weather concentrations represent minimum and maximum geometric means of wet weather events, available from the current limited data base.

NOTE: Review of source reports is recommended for interpretational purposes.

TABLE 5.1.2: MEAN ANNUAL VOLUMETRIC DISCHARGES TO HUMBER BAY
(based on 1984 data)

SOURCE	DISCHARGE ($m^3/yr \times 10^6$)
Humber Sewage Treatment Plant	123.7
Humber River	218.5
Mimico Creek	24.0
Etobicoke Waterfront	N/A
Combined and Storm Sewers East of the Humber River	1.3[1]

1 - Dorsch Consult Limited, Study on Operational Behaviour of Principal City Interceptor Sewers, Volume 1,(1978), p. 4.37.

TABLE 5.1.3: SUMMARY OF LOADINGS TO HUMBER BAY

	DIRECT INPUTS (kg/year)*					
PARAMETER	STP	CSO	Mimico Creek	Etobicoke Waterfront	Humber River	Atmosphere
Fecal Coliform (FC)	181.2×10^{14}	19.9×10^{14}	0.6×10^{14}	0.3×10^{14}	50.5×10^{14}	NA
Total Phosphorus (TP)	177 000	2 548	8 275	1 159	56 200	NA
Suspended Solids (SS)	3 242 000	170 300	2 075 000	290 500	31 300 000	NA
Cadmium (Cd)	387	8	16	2	126	NA
Copper (Cu)	2 887	155	510	71	5 730	5
Lead (Pb)	1 661	237	688	96	4 470	200
Nickel (Ni)	21 700	N/A	287	40	1 500	41
Zinc (Zn)	16 100	390	1 913	268	7 540	168
Mercury (Hg)	33	N/A	0.8	0.1	9	NA
Chromium (Cr)	1 883	N/A	514	72	1 870	NA

* Bacteria loadings are in organisms/year.

** Loads were calculated using 1979/80 flows.

*** Since no pollutant concentration data is available for the storm sewer outfalls along the Etobicoke waterfront, the waterfront pollutant loads were calculated by multiplying Mimico Creek loadings by a watershed area ratio (factor = 13 sq. km divided by 90 sq. km. = 0.14).

**** Fecal coliform inputs from the STP, occur largely during the winter season when disinfection is discontinued.

NA Not available or not applicable.

TABLE 5.1.4 - QUALITATIVE LOAD ASSESSMENT

Parameter	Major Sources	Minor Sources
Fecal Coliform	STP (winter season) CSO Humber River	Mimico Creek Etobicoke Waterfront
Phosphorus	STP Humber River	Mimico Creek CSO Etobicoke Waterfront
Suspended Solids	Humber River	STP Mimico Creek Etobicoke Waterfront CSO
Metals	STP Humber River	Mimico Creek CSO Etobicoke Waterfront

The Humber STP, CSO discharges and the Humber River, dominate the bacterial loading to the Bay. However, the Humber STP loadings occur largely during the winter season when chlorination of the effluent is discontinued. Chlorination is resumed again in the spring since the control of bacteria is of particular importance for body contact during the summer season. It is apparent therefore that the CSO and the Humber River bacterial inputs may be relatively more significant, especially during and immediately after wet weather events.

Mimico Creek and the Etobicoke waterfront, are secondary sources of pollutants. Secondary sources are capable of producing localized impacts, especially for bacteria. However, the impact on Humber Bay, is relatively small.

Description of major input sources to Humber Bay are given below.

5.2 HUMBER STP

The Humber Sewage Treatment Plant is a conventional activated sludge treatment plant with a design capacity of 410 x 10^3 m^3/day. It services a total area of 18,664 ha. Four cities of Metro Toronto are situated either partly or wholly in this area including Etobicoke, North York, Toronto and York, as outlined in Figure 5.2.1.

The Humber STP discharges an average of 339 x $10^3 m^3$/day (1984) into Humber Bay. Pollutant concentrations in the effluent, are measured once per month by the Metropolitan Toronto Laboratory.

Seasonal chlorine disinfection is practised from April 1 to October 15. Data collected in 1983 and 1984 resulted in geometric mean coliform concentrations as indicated in Table 5.2.1.

TABLE 5.2.1 - HUMBER STP EFFLUENT COLIFORM CONCENTRATIONS

Disinfection	Chlorine Residual (mg/L)	Geometric Mean Total Coliform (/100 mL)	Geometric Mean Fecal Coliform (/100 mL)
On	0.6	2 200	1 700
Off	0	350 000	30 000

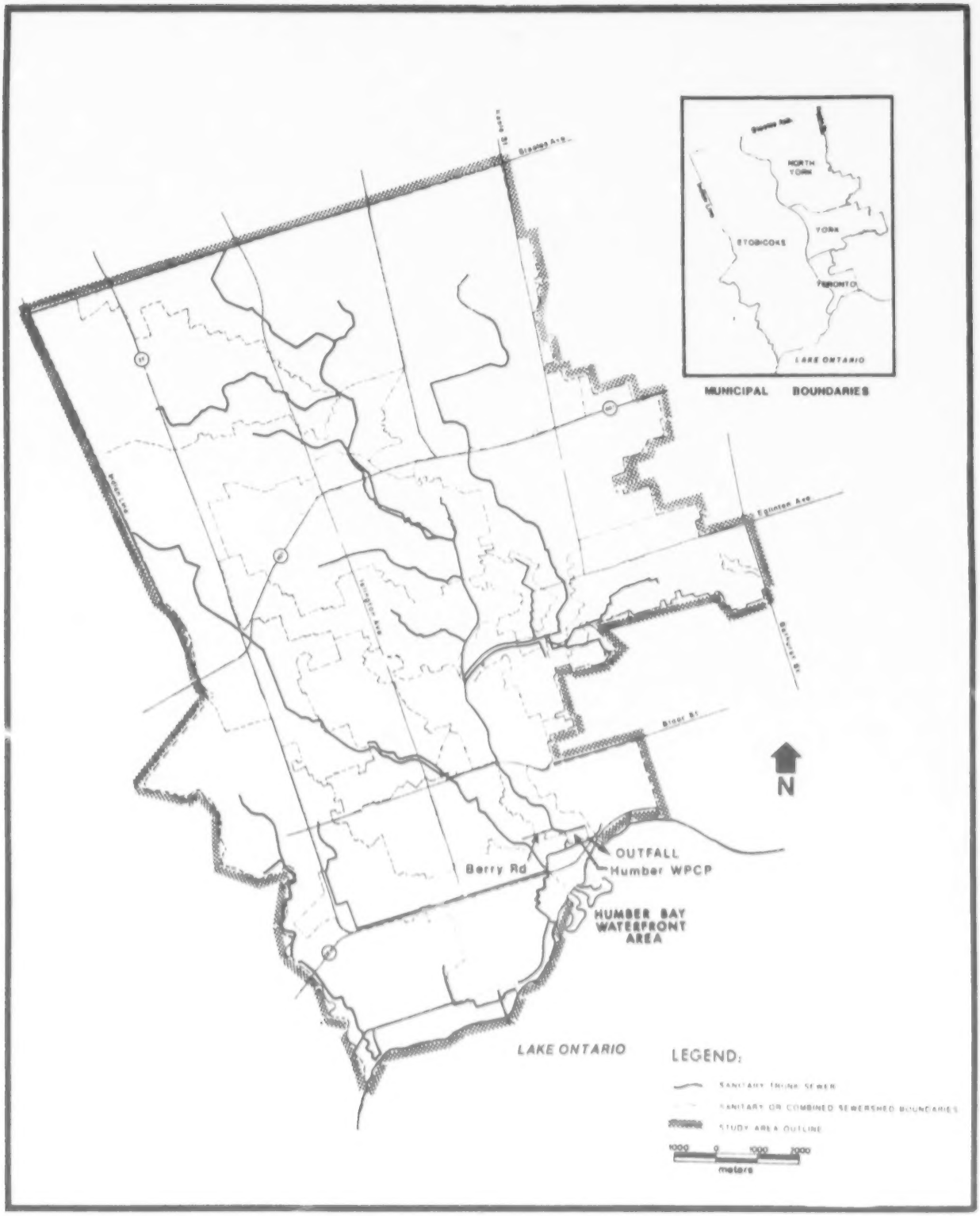


FIGURE 5.2.1: HUMBER SEWERSHED : SANITARY AND COMBINED SEWER KEY MAP

5.3 COMBINED SEWERS

The Combined Sewer System in the City of Toronto draining into the three main interceptors and overflowing at some locations into the parallel road storm sewer system, terminates at the Main Sewage Treatment Plant at Ashbridge's Bay and is independent of the Humber STP. This system services an approximate area of 6,630 ha. Only a portion of the combined and storm sewer outfalls in the serviced area contribute pollutant loads to Humber Bay; overflows are discharged directly into Lake Ontario (western beaches), the Toronto Inner Harbour, the Don River, the Turning Basin or Ashbridge's Bay.

The three interceptor sewers receive dry weather flow (DWF) and some storm flow from the drainage area to the north of each interceptor sewer (see Figure 5.3.1). During wet weather conditions, discharges to the western beaches occur through combined sewer overflow and storm sewer outfalls. These outfalls are intermittent nearshore sources contributing short term 'event' pollutant loads.

The Department of Public Works of the City of Toronto carries out routine monitoring and has an effluent quality sampling program to detect any escape of DWF from overflow structures at sewer outlets into receiving water bodies.

5.4 MIMICO CREEK

The Mimico Creek watershed is one of the most highly urbanized areas within the jurisdiction of the Metropolitan Toronto and Region Conservation Authority. The high pollutant concentrations observed at the mouth of Mimico Creek, as indicated in Table 5.1.1, confirm the impact of urbanization on the area.

Mimico Creek drains an approximate watershed area of 90 km^2 and discharges into Lake Ontario within the City of Etobicoke, at Lakeshore Boulevard, immediately to the west of Park Lawn Road. The presence of paved surfaces and impermeable soils, combined with sewerage inflows and steep stream gradients and the absence of natural storage areas within the watershed, result in 'flashy' responses to precipitation and high rates of runoff. During the summer and early fall, recorded flows often fall to less than 0.06 cubic meters per second as the stream approaches an intermittent state. Mimico Creek therefore impacts Humber Bay on a wet event basis more than on a continuous basis.

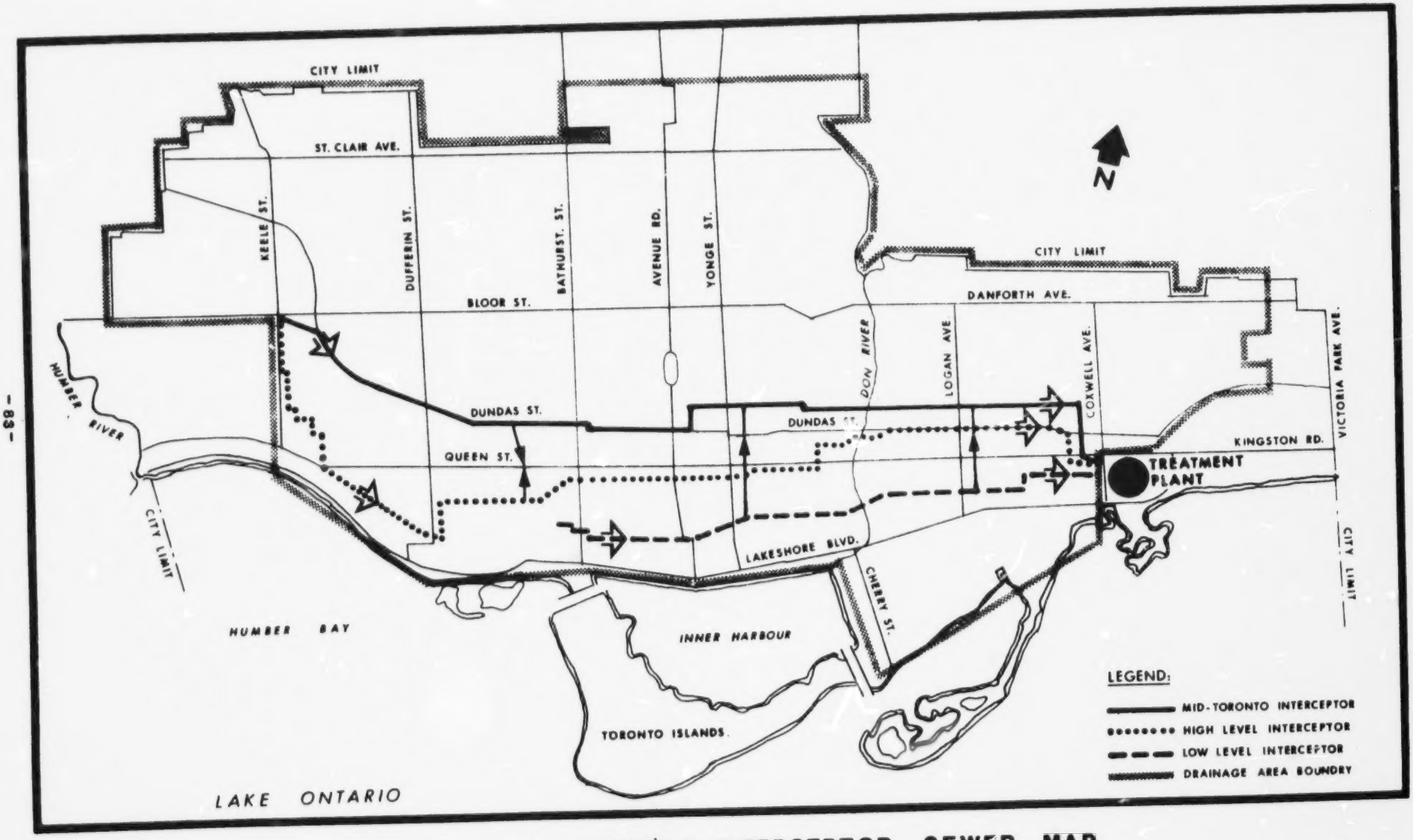


FIGURE 5.3.1. TORONTO INTERCEPTOR SEWER MAP

5.5 HUMBER RIVER

The Humber River drains a watershed area of approximately 897 km². The watershed can be divided into upper and lower sections. The upper portion is mainly rural. The lower portion is a highly developed area of Metropolitan Toronto.

The drainage system of the urbanized portion is primarily a separate sewer system (sanitary and storm). Storm sewers contribute directly into the receiving waters of the Humber River and tributaries. Inputs consist of dry as well as wet weather contributions. In addition, a portion of the drainage area operates under a combined sewer system, that contributes to the receiving stream only intermittently, during wet weather (combined sewer overflows).

Water quality in the Humber River watershed is presently monitored by five Provincial Water Quality Monitoring Network (PWQMN) stations, with additional data sets collected under the Toronto Area Watershed Management Strategy (TAWMS) program. For the purpose of this analysis, data sets from the Bloor Street monitoring station were used, supplemented by data from the Lakeshore Road and Dundas Street stations.

5.6 ETOBICOKE WATERFRONT

The Etobicoke Waterfront drains an area approximately 13 km² along the Lake Ontario shoreline. During wet weather, storm sewer outlets along the Etobicoke waterfront discharge stormwater runoff directly into Humber Bay. These outlets are considered to be nearshore diffuse sources and contribute short term 'event' pollutant loads.

5.7 ATMOSPHERIC DEPOSITION

The atmospheric inputs to Humber Bay were estimated assuming that the area of interest covers approximately 22 km^2 (i.e., the depositional zone of low wave-energy).

Deposition rates were taken largely from the APIOS monitoring network results (Tang et al 1986, Tang et al, 1983), and also from W. Strachan (CCIW, oral communication). Values were interpolated to the Toronto area, and the resulting estimates of total deposition are shown in the Table below.

Contaminant	Deposition $kg\ y^{-1}$
lead	200[1]
zinc	168[1]
cadmium	5[2]
copper	41[2]
nickel	17[2]
PCDDs & PCDFs	0.0007[3]
PCBs	0.07[3]
chlorobenzenes	0.001[3]

[1] Tang et al 1986
[2] Tang et al 1983
[3] W. Strachan

Note that these estimates of atmospheric deposition are probably on the low side, since they are values interpolated from rural monitoring stations, and do not reflect the impact of the Toronto area itself on local atmospheric deposition. Based on a few measurements for trace metal deposition at a site in downtown Toronto, the true atmospheric deposition to Humber Bay could be as much as fivefold higher than the values shown in the above Table.

6.0 REMEDIAL PROGRAMS AND RELATED STUDIES

In response to beach postings in 1983, the Humber Bay area has undergone major rehabilitation. In 1984 a deflector jetty was constructed along the eastern section of the Humber River mouth in an effort to deflect the polluted Humber River waters from entering behind the breakwall. The existing sandy beach was thoroughly cleaned of debris and new sand was deposited along its entire stretch in order to

create a more aesthetically pleasing environment. Along the western sector, the City of Etobicoke Works Department now routinely removes filamentous growth of the alga Cladophora within 3 feet of the shoreline using an algae skimmer in order to render the area more aesthetically pleasing.

In addition, numerous studies and programs have been initiated with the aim of developing remediation strategies for the entire Metro Toronto waterfront. Those programs and studies which have a bearing on the Humber Bay area are briefly described below. More detailed information may be obtained from the published documents which are referenced in these sections.

6.1 METRO TORONTO REMEDIAL ACTION PLAN (RAP)

Since 1973, the Great Lakes Water Quality Board (GLWQB) of the International Joint Commission (IJC), in its annual assessments of water quality in the Great Lakes, has identified specific Areas of Concern, such as harbours, river mouths and connecting channels, which have serious pollution problems. These areas are defined as geographical locations in the boundary waters where one or more of the general or specific IJC water quality objectives or jurisdictional standards or criteria were not being met, and where beneficial uses were or could be impaired.

Methods for classifying Areas of Concern have changed over the years. In its 1985 report, the GLWQB presented a new criteria for classifying a total of 42 Areas of Concern. Under this new classification, the Toronto Waterfront Area of Concern has been identified in Category 3. The definition of this Category is that "causative factors are known, but a Remedial Action Plan is not yet developed and remedial measures are not yet fully implemented".

In 1985, the GLWQB recommended that the responsible jurisdictions complete and submit a RAP for the Metro Toronto Waterfront. In response to this recommendation, the federal-provincial Metropolitan Toronto RAP Team was established in June of 1986 to coordinate the development of the Metro Toronto Waterfront RAP.

A comprehensive Remedial Action Plan for the Metro Toronto Waterfront is presently being developed by the Ontario Ministry of the Environment and Environment Canada in co-operation with other agencies in an effort to provide a strategy for abatement which would result in an improved aquatic environment. This document is intended to present a comprehensive overview of pollution problems in the Metro Toronto Waterfront and propose remedial measure options required to abate these problems. The City of Toronto through the Toronto Waterfront Remedial Action Plan Committee has prepared its own remedial action plan entitled "A Remedial Action Plan for the Toronto Waterfront" commonly referred to as the "WRAP" (City of Toronto, 1986). It is the intention of the provincial-federal RAP team to incorporate the WRAP document into its RAP.

The provincial-federal plan will be developed with full public participation. A Public Involvement Committee has been set up to educate the public on pollution issues and to obtain public's views on desired uses and goals for rehabilitation of Metropolitan Toronto's Waterfront. The public will also have an opportunity for full involvement in the selection of remedial options. The final RAP document will be submitted to the International Joint Commission.

6.2 MUNICIPAL INDUSTRIAL STRATEGY FOR ABATEMENT (MISA)

The Ontario Ministry of Environment has embarked on a Municipal Industrial Strategy for Abatement" (MISA) which is aimed at controlling municipal and industrial discharges into surface waters. Its goals and objectives are outlined in a recently published document (MOE, 1986). In addition to reducing pollution from direct dischargers, MISA also seeks to cut contamination from industries discharging waste water into municipal sewer systems which, in turn, discharge to the waterways. This will be accomplished by setting strict pollution control standards for municipal sewage treatment plant effluent, including the Humber STP.

For the first time, the total amount of each toxic contaminant from a polluter will be limited. This will be accomplished by requiring each direct discharger to meet standards attainable by the best available pollution abatement technology. More stringent abatement techniques

may be required in the case of discharge to highly sensitive aquatic areas. These areas will receive individual aquatic monitoring and discharge standards to be set accordingly. Out of six pilot sites presently under study, one, the Toronto Main STP, is located in the Toronto Waterfront Area. Certain aspects of this study will be applicable to the Humber STP. The component of MISA dealing with municipal discharges will be in place by December 1989.

6.3 TORONTO AREA WATERSHED MANAGEMENT STRATEGY (TAWMS)

In 1981, the Ontario Ministry of the Environment initiated a study of Water quality problems in the Don River, Humber River and Mimico Creek watersheds. While this program is primarily intended to foster water quality improvement in the rivers themselves, it is expected to significantly benefit the Toronto waterfront. The objectives of TAWMS are:

- To better define water quality conditions within the study area.

- To analyse the cause and effect relationships for problem constituents and areas.

- To develop cost-effective measures for controlling pollutant loadings to the study area's receiving waters based on watershed needs and uses.

Following investigations over the period 1982-85 (TAWMS Technical Reports 1-10), the Humber River Water Quality Management Plan was released in July 1986. The report recommends implementation of a number of structural and non-structural measures and pilot projects aimed at cost-effective control of both point and non-point sources of pollution in the Humber watershed. Included are:

- combined sewer overflow storage and treatment
- stormwater retention and treatment (industrial and residential)
- spill prevention and improved wastewater management practices in industrial areas
- catchbasin cleaning
- residential control of hazardous chemicals
- dog litter control

The Water Quality Management Plan for the Humber watershed has gone through a public consultation process and has received valuable input. An Implementation Committee has been set up to oversee the implementation of the plan.

The Ministry of the Environment has provided $2.9 million funding to TAWMS investigations to the end of fiscal 1986/87 and has earmarked an additional $200 thousand for studies in 1987/88.

6.4 MOE/METRO AGREEMENTS

Concurrently with TAWMS, the Ministry has entered into Agreements with the Municipality of Metropolitan Toronto to provide funds to the local municipalities for special remedial works and investigations. Projects covered under these agreements have included:

- sewer separation
- cross-connection correction
- inlet control works
- physical shoreline improvements
- disinfection pilot studies
- combined and storm sewer monitoring and investigation
- ambient water quality monitoring

Over the period 1984 to 1986, MOE has contributed over $12.7 million to Metro under these agreements. The total cost of work undertaken by the municipalities under the agreement programs has exceeded $24 million.

/ml/rmg
00716-07A

REFERENCES

Barton, D.R., 1980. Some Nearshore Benthic Macroinvertebrates from Humber Bay and Toronto Harbour, Lake Ontario and Long Point Bay, Lake Erie. University of Waterloo for Supply and Services Canada. 27 pp.

Cabelli, V.J., 1983. Health effects criteria for marine recreational waters. EPA-600/1-80-031. 98 pp.

City of Toronto, 1986. A Remedial Action Plan for the Toronto Waterfront. Prepared by the Toronto Waterfront Remedial Action Plan Committee. 136 pp.

Cockburn, P.G., 1976. The Effects of two Toronto Waterfront Landfill Sites on the benthic invertebrates of inshore waters of Lake Ontario. Internal Ministry of the Environment Report. 19 pp.

Dewailly, E., C. Poirieu, F.M. Meyer, 1986. Health hazard associated with windsurfing on polluted waters. American Journal of Public Health, June 1986, Vol. 76, No. 6, p. 690-691.

Dorsch, 1978. Study on operational behaviour of principal city interceptor sewers, Volume 1.

Dufour, A.P., 1984. Health effects criteria for fresh recreational waters. Cincinnati, Ohio. E.P.A.-600/1-84.

El-Shaarawi, A.H. and R.E. Kwiatkowski, 1977. A model to describe the inherent spatial and temporal variability of parameters in Lake Ontario 1974. J. Great Lakes Res. Dec. 1977.

E.P.A., 1986. Ambient Water Quality Criteria for Bacteria - 1986. P.B. 86-1580945. 17 pp.

Gore and Storrie, 1986. Western Beaches Study, 1985 fo Department of Public Works, City of Toronto.

Hunter and Associates, 1985. Humber River plume monitoring by time lapse video, July 28 to September 30, 1984 and November 2 to December 11, 1984 for Ministry of Environment.

IJC, 1983. Annual Report of Great Lakes Science Advisory Board to the International Joint Commission. November 1983. Windsor, Ontario.

Kleinfeldt, 1986. Local influences on the water quality of the Western Beaches, Toronto, Ontario. Prepared for City of Toronto Department of Public Works.

Kohli, B., 1986. Humber Bay Circulation 1983-84. Unpublished MOE report.

Kohli, B., 1982. Flow Structure of Eastern Toronto Waterfront, Lake Ontario, 1981. MOE, Toronto, Ontario. 135 pp.

Metropolitan Toronto, 1984. Trace Organic Analyses of Water Pollution Control Effluents, Report 1.

Metropolitan Toronto, 1983. Trace Organic Analyses of Water Pollution Control Effluent, Report 2.

MOE, 1986. Municipal-Industrial Strategy for Abatement (MISA).

MOE, 1986. Guide to Eating Ontario Sport Fish, Southern Ontario, Great Lakes, 1985-1986. MOE, Toronto, Ontario.

MOE, 1985. Humber River Plume Tracking, Report by Water Resources Branch, MOE, Toronto, Ontario.

MOE, 1984. Water Management, Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment, November 1978, revised May 1984.

Persaud, D., T. Lomas, D. Boyd and S. Mathai, 1985. Historical Development and Quality of the Toronto Waterfront Sediments, Part I. MOE report.

Suns, K., G.E. Crawford, D.D. Russell and R.E. Clement, 1985. Temporal Trends and Spatial Distribution of Organochlorine and Mercury Residues in Great Lakes Spottail Shiners (1975-1985). A MOE Report, Toronto, Ontario.

Tang, A. et al, 1986. Summary: Some Results from the APIOS Atmospheric Deposition Monitoring Program. Draft MOE Report ARB-110-36.

Tang, A. et al, 1986. Precipitation and .... Concentration and Wet and Dry Deposition Fields of Pollutants in Ontario - 1983. MOE Report ARB-008-86-AQM.

TAWMS, Technical Report #1, 1983, "Humber River and Tributary Dry Weather Outfall Survey", Gartner Lee and Associates Limited, Toronto, Ontario.

TAWMS, Technical Report #3, 1984, "Physical Characteristics of the Humber River", Klose, S., Bacchus, A., Ontario Ministry of the Environment, Toronto, Ontario.

TAWMS, Technical Report #4, 1984, "Humber River and Toronto Area Water Quality", Acres Consulting Services Limited, Niagara Falls, Ontario.

TAWMS, Technical Report #5, 1984, "Development of a Model (HAZPRED) for Predicting the Incidence of Hazardous Contaminants in Raw Sewage - Phase 1", Canviro Consultants Limited, Kitchener, Ontario.

TAWMS, Technical Report #6, 1986, "Humber River Bacteriological Study", Gore and Storrie Limited, Toronto, Ontario.

TAWMS, Technical Report #7, 1986, "Combined Sewer Overflow Study", Wong, W., Ontario Ministry of the Environment, Toronto, Ontario.

TAWMS, Technical Report #8, 1986, "Upper Humber River Water Quality Study", Hindley, B., Hubbard, R., and Maude, S., Metropolitan Toronto and Region Conservation Authority, Toronto, Ontario.

TAWMS, Technical Report #9, 1986, "Feasibility Study and Costing of Proposed Pollution Control Measures in the Humber Sewershed", Paul Theil Associates Limited, Bramalea, Ontario.

TAWMS, Technical Report #10, 1986, "Sediment Transport and Associated C Contaminant Movement Within the Humber River", Klose, S., Ontario Ministry of the Environment, Toronto, Ontario.

APPENDIX

Table A-1: METAL LEVELS IN HUMBER BAY WATERS, NEAR MAJOR SOURCES, 1983, 1985

Parameter	PWQO	Min. Rep. Amount	Year		LOCATIONS Stn. 2054 Mouth Mimico Cr.	Stn. 2072 at STP Outfall	Stn. 9053 Mouth Humber R.
Arsenic	100	1	1983	N	2	4	1
				Max.	1	1	1
ug/L				Min.	1	ND	ND
				Median	D	D	D
				%>MRA	100	50	50
				%>PWQO	0	0	0
			1985	N	12	12	12
				Max.	1	1	1
				Min.	ND	ND	ND
				Median	D	D	ND
				%>MRA	50	66	33
				%>PWAO	0	0	0
Barium	-	2	1983	N	2	4	2
				Max.	29	39	32
ug/L				Min.	22	24	32
				Median	25.5	29	ND
				%>MRA	100	100	100

Table A-1 (cont'd): METAL LEVELS IN HUMBER BAY WATERS, NEAR MAJOR SOURCES, 1983, 1985

Parameter	PWQO	Min. Rep. Amount	Year		LOCATIONS Stn. 2054 Mouth Mimico Cr.	Stn. 2072 at STP Outfall	Stn. 9053 Mouth Humber R.
Beryllium	1100	1	1983	N	2	4	2
				Max.	ND	1	ND
ug/L				Min.	ND	ND	ND
				Median	ND	1	ND
				%>MRA	ND	25	0
				%>PWQO	0	0	0
Cadmium	0.2	0.2	1983	N	2	4	2
				Max.	0.4	2	0.2
ug/L				Min.	0.4	0.4	ND
				Median	0.4	1.2	0.2
				%>MRA	100	100	50
				%>PWQO	100	100	50
			1985	N	12	12	12
				Max.	0.7	0.8	0.3
				Min.	ND	ND	ND
				Median	<0.2	0.3	<0.2
				%>MRA	25	66	25
				%PWQO	25	58	16

Table A-1 (cont'd): METAL LEVELS IN HUMBER BAY WATERS, NEAR MAJOR SOURCES, 1983, 1985

Parameter	PWQO	Min. Rep. Amount	Year		LOCATIONS Stn. 2054 Mouth Mimico Cr.	Stn. 2072 at STP Outfall	Stn. 9053 Mouth Humber R.
Chromium	100	0.2	1983	N	2	4	2
				Max.	3	50	6
ug/L				Min.	3	2	4
				Median	3	20.7	5
				%>MRA	100	100	100
				%>PWQO	0		
			1985	N	12	12	12
				Max.	5.0	18.0	9.0
				Min.	1.0	3.0	< 1.0
				Median	3.0	8.0	4.0
				%>MRA	100	100	83
				%>PWQO	0	0	0
Cobalt	-	1	1983	N	2	4	2
				Max.	2	1	ND
ug/L				Min.	1	ND	ND
				Median	1.5	1	ND
				%>MRA	100	75	0

Table A-1 (cont'd): METAL LEVELS IN HUMBER BAY WATERS, NEAR MAJOR SOURCES, 1983, 1985

Parameter	PWQO	Min. Rep. Amount	Year		LOCATIONS Stn. 2054 Mouth Mimico Cr.	Stn. 2072 at STP Outfall	Stn. 9053 Mouth Humber R.
Copper	5	1	1983	N	2	4	2
				Max.	35	31	29
ug/L				Min.	8	22	19
				Median	21.5	35	24
				%>MRA	100	100	100
				%>PWQO	100	100	100
			1985	N	12	12	12
				Max.	7.0	20.0	7.0
				Min.	1.0	5.0	1.0
				Median	3.0	8.0	3.0
				%>MRA	100	100	100
				%>PWQO	42	83	33
Iron	300	18	1983	N	2	4	2
				Max.	2800	1500	630
ug/L				Min.	280	670	340
				Median	2540	1100.5	485
				%>MRA	100	100	
				%>PWQO	50	100	50
			1985	N	12	12	12
				Max.	340.0	970.0	1400.0
				Min.	69	80.0	42.0
				Median	110.0	585.0	285.0
				%>MRA	100	100	100
				%>PWQO	16	91	25

Table A-1 (cont'd): METAL LEVELS IN HUMBER BAY WATERS, NEAR MAJOR SOURCES, 1983, 1985

Parameter	PWQO	Min. Rep. Amount	Year		LOCATIONS Stn. 2054 Mouth Mimico Cr.	Stn. 2072 at STP Outfall	Stn. 9053 Mouth Humber R.
Lead	25	1	1983	N	2	4	2
				Max.	29	11	8
ug/L				Min.	5	4	6
				Median	17	6	7
				%>MRA	100	100	100
				%>PWQO	50	0	0
			1985	N	12	12	12
				Max.	7.0	74	6.0
				Min.	3.0	2.0	3.0
				Median	3.5	3.5	4
				%>MRA	50	33	58
				%>PWQO	0	8	0
Manganese	25	1	1983	N	2	4	2
				Max.	66	33	36
ug/l				Min.	8	16	25
				Median	37	26	30.5
				%>MRA	100	100	100
				%>PWQO	50	50	0
			1985	-	-	-	

Table A-1 (cont'd): METAL LEVELS IN HUMBER BAY WATERS, NEAR MAJOR SOURCES, 1983, 1985

Parameter	PWQO	Min. Rep. Amount	Year		LOCATIONS Stn. 2054 Mouth Mimico Cr.	Stn. 2072 at STP Outfall	Stn. 9053 Mouth Humber R.
Mercury		.02	1983	N	1	2	1
				Max.	0.07	0.05	0.02
(Total				Min.	0.07	ND	0.02
Unfiltered)				Median	0.07	0.05	0.02
ug/L				%>MRA	100	50	100
			1985	N	12	12	
				Max.	0.07	0.18	0.03
				Min.	ND	ND	ND
				Median	0.04	0.03	ND
				%>MRA	50	83	41
Molybdenum	-	1	1983	N	2	4	2
				Max.	ND	2	2
ug/L				Min.	ND	1	1
				Median	ND	1.5	1.5
				%>MRA	0	50	100

Table A-1 (cont'd): METAL LEVELS IN HUMBER BAY WATERS, NEAR MAJOR SOURCES, 1983, 1985

Parameter	PWQO	Min. Rep. Amount	Year		LOCATIONS Stn. 2054 Mouth Mimico Cr.	Stn. 2072 at STP Outfall	Stn. 9053 Mouth Humber R.
Nickel	25	2	1983	N	2	4	2
				Max.	8	53	4
ug/L				Min.	3	3	2
				Median	5.5	20	3
				%>MRA	100	100	100
				%>PWQO	0	50	0
			1985	N	12	12	12
				Max.	14.0	30.0	6
				Min.	2.0	2.0	2.0
				Median	4.5	22.5	3.5
				%>MRA	100	100	83
				%>PWQO	0	25	0
Selenium	100	1	1983	N	2	4	2
				Max.	ND	ND	ND
ug/L				Min.	ND	ND	ND
				Median	ND	ND	ND
				%>MRA	0	0	0
				%>PWQO	0	0	0

Table A-1 (cont'd): METAL LEVELS IN HUMBER BAY WATERS, NEAR MAJOR SOURCES, 1983, 1985

Parameter	PWQO	Min. Rep. Amount	Year		LOCATIONS Stn. 2054 Mouth Mimico Cr.	Stn. 2072 at STP Outfall	Stn. 9053 Mouth Humber R.
Strontium	-	1	1983	N	2	4	2
ug/L				Max.	150	150	170
				Min.	100	140	170
				Median	125	145	170
				%>MRA	100	100	100
Titanium	-	1					
ug/L			1983	N	2	4	2
				Max.	18	78	3
				Min.	5	ND	2
				Median	115	7	2.5
				%>MRA	100	25	100

Table A-1 (cont'd): METAL LEVELS IN HUMBER BAY WATERS, NEAR MAJOR SOURCES, 1983, 1985

Parameter	PWQO	Min. Rep. Amount	Year		LOCATIONS Stn. 2054 Mouth Mimico Cr.	Stn. 2072 at STP Outfall	Stn. 9053 Mouth Humber R.
Vanadium	-	1	1983	N	2	4	2
				Max.	5	3	3
ug/L				Min.	1	2	2
				Median	3	2.5	1.5
				%>MRA	100	50	100
Zinc	30	1	1983	N	2	4	2
				Max.	68	120	50
ug/L				Min.	6	6	27
				Median	37	46.5	38.5
				%>MRA	100	100	100
				%>PWQO	50	50	50
			1985	N	12	12	12
				Max.	50.0	80.0	16
				Min.	4.0	3.0	1.0
				Median	14.0	30.0	6.5
				%>MRA	100	100	100
				%>PWQO	16	33	0

Table A-2: ORGANOCHLORINE LEVELS IN HUMBER BAY WATERS, NEAR MAJOR SOURCES 1983, 1985

Parameter	PWQO	Min. Rep. Amount	Year		LOCATIONS Stn. 2054 Mouth Mimico Cr.	Stn. 2072 at STP Outfall	Stn. 9053 Mouth Humber R.
αBHC	-	1	1983	N	2	4	2
				Max.	6	3	4
ng/L				Min.	ND	2	2
				Median	6	2.5	3
				%>MRA	50	75	100
			1985	N	12	12	12
				Max.	3	3	4
				Min.	ND	ND	ND
				Median	2	2	ND
				%>MRA	50	25	33
β BHC	-	1	1983	N	2	4	2
				Max.	ND	1	ND
ng/L				Min.	ND	ND	ND
				Median	ND	1	ND
				%>MRA	ND	25	0
			1985	N	12	12	12
				Max.	2	ND	2
				Min.	ND	ND	ND
				Median	ND	ND	ND
				%>MRA	16	0	16

Table A-2 (cont'd): ORGANOCHLORINE LEVELS IN HUMBER BAY WATERS, NEAR MAJOR SOURCES 1983, 1985

Parameter	PWQO	Min. Rep. Amount	Year		LOCATIONS Stn. 2054 Mouth Mimico Cr.	Stn. 2072 at STP Outfall	Stn. 9053 Mouth Humber R.
δBHC	10	1	1983	N	2	4	2
				Max.	2	3	ND
ng/L				Min.	ND	1	ND
				Median	2	2	ND
(Lindane)				%>MRA	50	75	0
				%>PWQO	0	0	0
			1985	N	12	12	12
				Max.	5	6	2
				Min.	ND	ND	ND
				Median	4	ND	ND
				%>MRA	1	33	50
				%>PWQO	0	0	0
1,2,3,4 Tetrachloro benzene ng/L	100	1	1985	N	12	12	12
				Max.	ND	3	ND
				Min.	ND	ND	ND
				Median	ND	ND	ND
				%>MRA	0	8	ND
				%>PWQO	0	0	C
1,2,4 Tricloro benzene ng/L	500	5	1985	N	12	12	12
				Max.	8	ND	ND
				Min.	ND	ND	ND
				Median	ND	ND	ND
				%>MRA	ND	ND	ND
				%>PWQO	0	0	0

Table A-2 (cont'd): ORGANOCHLORINE LEVELS IN HUMBER BAY WATERS, NEAR MAJOR SOURCES 1983, 1985

Parameter	PWQO	Min. Rep. Amount	Year		LOCATIONS Stn. 2054 Mouth Mimico Cr.	Stn. 2072 at STP Outfall	Stn. 9053 Mouth Humber R.
Pentachloro-phenol ng/L	500	50	1985	N	12	12	12
				Max.	ND	60	ND
				Min.	ND	ND	ND
				Median	ND	ND	ND
				%>MRA	ND	8	ND
				%>PWQO	0	0	0
HCB ng/L	6.5	1	1985	N	12	12	12
				Max.	4	4	2
				Min.	2	1	1
				Median	2.5	2	1.5
				%>MRA	33	25	33
				%>PWQO	0	0	0